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SOME BIOMETRICS OF *HELICONIUS CHARITONIUS* (LINNAEUS) (LEPIDOPTERA, NYMPHALIDAE)

By F. Martin Brown and William P. Comstock

Some years ago one of us (Brown) made a series of measurements on the specimens of *Heliconius charitonius* (Linnaeus) in the American Museum of Natural History. The outbreak of World War II put an end to the study that had been planned. Recently the other (Comstock) gathered together the specimens of this species from several museums and private collections and greatly augmented the original data that had been accumulated. This led to the writing of "Geographical variation and subspeciation in *Heliconius charitonius* Linnaeus (Lepidoptera, Nymphalidae)" by us (1950, Amer. Mus. Novitates, no. 1467), in which a number of races of the species were recognized.

The present study was made by Brown, by treating the data compiled by Comstock with accepted statistical procedures. Its conclusions are based on a limited number of measurable characters, without reference to the insects themselves. It might be considered an inquiry into the effectiveness of statistical processes as aids in the taxonomy of butterflies, and also as a study of the geographic variation of a relatively static species with a rather wide range.

MEASUREMENTS

The measurements made were described in the above-mentioned paper (Comstock and Brown, 1950, Amer. Mus. Novitates, no. 1467). They fall into two categories: linear measures and frequencies. The former are treated here with the well-known and

often-used statistics of central tendencies: arithmetic mean, standard deviation, probable error, and coefficient of variation. The latter are treated with the less frequently applied statistics of the point-binomial theorem. The results of these statistical inquiries are presented in both tabular and graphic form.

THE MEASURE OF SIZE

To determine the inter- and intra-population variations in size, a single measure was used, i.e., the maximum radius of the left forewing. The measurements were made by Comstock, using a vernier caliper and reading to 0.1 mm. Each individual was measured twice, with a considerable interval of time between measurings. These data were treated statistically by Brown. Four parameters were determined for each population studied: mean, probable error of the mean, standard deviation, and coefficient of variation. Certain discrete populations were pooled for a single set of parameters, when the samples from the smaller populations demonstrated no significant differences. Thus the Virgin Islands parameters are based on series from St. Thomas, St. John, St. Croix, and Tortola, and the Central American parameters are based on series from each of the republics from Guatemala to Panama. This latter population may prove upon study of a much larger series to be worthy of treatment as a northern and southern population divided by the Nicaragua-Costa Rica border.

The mean population "size" is 38.94 mm. Within the species there is a general tendency for the size to vary with the latitude. The northern samples tend to be composed of larger individuals than the southern populations. If all the samples, mainland and Antillean, are considered together, the coefficient of correlation between size and latitude is $r = +0.6678 \pm 0.1752$. Since r is 3.8 times as large as its standard error, r can be considered to be significantly different from zero, even though the sample is small. The probability that there is no relationship between size and latitude is less than 1 in 6916.

If the mainland and insular populations are segregated, the direct relationship between size and latitude is even more strongly indicated.

Mainland Populations		Insular Populations	
Florida	41.82 mm.	Cuba	41.09 mm.
Mexico	41.81	Hispaniola	39.83
Central America	40.67	Jamaica	36.32
Colombia	37.84	Puerto Rico	38.68
West Peru	33.30	Virgin Islands	38.02

Because there is a definite cline in size apparently related to latitude, size alone must be used very cautiously as a taxonomic clue to subspeciation in *H. charitonius*. The appearance of a small-sized population in Jamaica that does not coincide with the clinal tendencies suggests that in this case size may be one of several characteristics that define a valid subspecies.

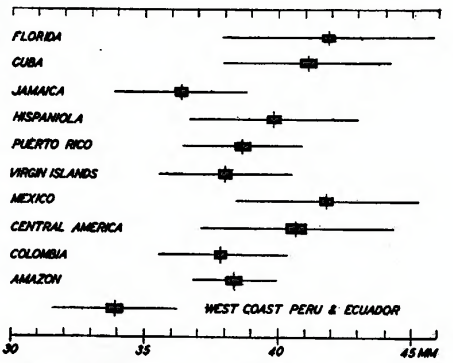

Fig. 1. Parameters of left forewing of males. The vertical cross line locates the mean of the sample studied, the probable error is expressed as a black block, and the standard deviation as a horizontal line.

The validity of the difference in size between two populations can be tested statistically. If the difference between two means is three or more times greater than the probable error of the difference, then the chance that the difference might be due solely to errors in sampling from a single population is less than 1 in 20. For this chance to be less than 1 in 100 the difference between the two means must be greater than 3.8 times its probable error. Since virtually any biological sample studied represents a really minute fraction of the whole population, rarely more than one-millionth in the case of a species such as *charitonius*, we doubt that a quotient less than 7.0 should be considered high enough to warrant the

difference's being of taxonomic value. Such a quotient means that the odds against its occurring between two samples drawn from the same population is 427,000 to 1.

In table 2 the differences in size between adjacent populations are stated in terms of the difference divided by its probable error. In this table "x" means that there is no biogeographic reason for comparing the populations in question. Some comparisons were made that had no biogeographic reason behind them. These are presented for the sake of arguments set forth below in this paper. The data necessary for computing any of the missing quotients can be found in table 1.

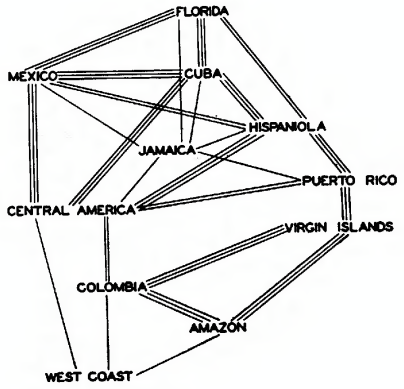

FIG. 2. Relationships of the different populations with regard to mean wing length. Three lines connecting two area names indicate that there is no real significance to the difference in mean size of the two samples studied. Two lines indicate some difference but of doubtful significance. One line indicates a significant difference.

From table 1 it is clear that the females tend to be a little larger than the males. The coefficients of variation are of the same order as those found for the lengths of appendages in man (about 5) to the more variable measures such as skull capacity (about 8).

An examination of table 2 shows that there are only two populations that clearly differ from all their neighbors in size. These are the material from Jamaica and that from the west coast of South America from the Rio Guayas southward.

THE MEASURE OF PATTERN PROMINENCE

A casual examination of a long series of *charitonius* grouped by populations makes it immediately evident that some populations are composed of individuals bearing yellow bands that are wider or narrower than those found in other populations. A standardized procedure was adopted to measure the width of these bands and was described in the original paper by Comstock and Brown.

TABLE 1

LENGTH (IN MILLIMETERS) OF THE LEFT FOREWING

Population	*N*	*M*	*P.E.*	*S.D.*	*V*
MALES					
Florida	125	41.82	±0.24	3.96	9.5
Cuba	43	41.09	±0.33	3.18	7.7
Jamaica	50	36.32	±0.24	2.52	6.9
Hispaniola	79	39.83	±0.24	3.17	8.0
Puerto Rico	30	38.68	±0.28	2.27	5.9
Virgin Islands	43	38.02	±0.26	2.53	6.7
Mexico	84	41.81	±0.25	3.43	8.2
Central America	37	40.67	±0.40	3.58	8.8
Colombia	64	37.84	±0.22	2.53	6.7
Amazon	14	38.34	±0.30	1.62	4.2
West coast of Peru and Ecuador	26	33.90	±0.32	2.35	6.9
FEMALES					
Florida	100	42.43	±0.24	3.58	8.4
Cuba	46	41.76	±0.35	3.51	8.4
Jamaica	28	37.47	±0.27	2.09	5.6
Hispaniola	74	41.02	±0.24	3.00	5.9
Puerto Rico	33	40.16	±0.29	2.45	6.1
Virgin Islands	27	39.69	±0.33	2.51	6.3
Mexico	52	43.18	±0.30	3.19	7.4
Central America	26	42.58	±0.44	3.22	7.6
Colombia	20	39.22	±0.58	3.75	9.6
Amazon	3	39.60	±1.87	3.93	9.9
West coast of Peru and Ecuador	17	35.67	±0.52	3.06	8.6

The accumulated data were processed in two forms: the direct measurements and these reduced to indices to eliminate the factor of specimen size. The index used was the width of the band divided by the length of the wing, and this quotient multiplied by 100. The data are presented in tables 3 and 4.

TABLE 2

SIGNIFICANCE OF THE DIFFERENCES IN MEAN WING LENGTH

Population		F.	C.	J.	Ha.	D.R.	H.	P.R.	V.I.	M.	C.A.	Co.	Am.	W.C.
Florida	♂	—	1.8	16.1	x	x	5.8	x	x	0.0	x	x	x	x
	♀	—	1.4	13.1	x	x	4.1	x	x	2.9	x	x	x	x
Cuba	♂	1.8	—	11.6	3.5	x	3.1	x	x	1.7	0.8	x	x	x
	♀	1.4	—	9.5	3.2	x	1.7	x	x	6.6	1.7	x	x	x
Jamaica	♂	16.1	11.6	—	8.3	x	10.8	x	x	15.6	9.2	x	x	x
	♀	13.7	9.5	—	8.1	x	9.9	x	x	15.0	13.4	x	x	x
Haiti	♂	x	3.5	8.3	—	2.2	—	x	x	5.8	2.3	x	x	x
	♀	x	3.2	8.1	—	4.7	—	x	x	6.8	5.2	x	x	x
Dominican Republic	♂	x	x	x	2.2	—	—	4.3	x	x	x	x	x	x
	♀	x	x	x	4.7	—	—	5.0	x	x	x	x	x	x
Hispaniola	♂	5.8	3.1	10.8	—	—	—	2.1	x	5.7	1.8	x	x	x
	♀	4.1	1.7	9.9	—	—	—	2.3	x	5.4	3.9	x	x	x
Puerto Rico	♂	x	x	x	x	4.3	2.1	—	1.7	8.2	4.1	x	x	x
	♀	x	x	x	x	5.0	2.3	—	2.1	7.6	6.0	x	x	x
Virgin Islands	♂	x	x	x	x	x	x	1.7	—	x	x	0.5	0.5	x
	♀	x	x	x	x	x	x	2.1	—	x	x	0.7	—	x
Mexico	♂	0.0	1.7	15.6	5.8	x	5.7	8.2	x	—	2.4	x	x	x
	♀	2.9	6.6	15.0	6.8	x	5.4	7.6	x	—	1.3	x	x	x
Central America	♂	x	0.8	9.2	2.3	x	1.8	4.1	x	2.4	—	6.2	x	14.8
	♀	x	1.7	13.4	5.2	x	3.9	6.0	x	1.3	—	5.1	x	11.3
Colombia	♂	x	x	x	x	x	x	x	0.5	x	6.2	—	0.9	12.6
	♀	x	x	x	x	x	x	x	0.7	x	5.1	—	—	4.6
Amazon[a]	♂	x	x	x	x	x	x	x	0.5	x	x	0.9	—	10.3
	♀	x	x	x	x	x	x	x	—	x	x	—	—	—
West Coast[a]	♂	x	x	x	x	x	x	x	x	x	14.8	12.6	10.3	—
	♀	x	x	x	x	x	x	x	x	x	11.3	4.6	—	—

[a] These data are based on Comstock's original data, without inclusion of the material in the Brown collection.

TABLE 3

BREADTH (IN MILLIMETERS) OF THE DISCAL BAND ON THE FOREWING

Population	*N*	*M*	*P.E.*	*S.D.*	*V*
MALES					
Florida	125	1.75	±0.02	0.27	15.4
Cuba	43	2.54	±0.03	0.27	10.6
Jamaica	50	2.72	±0.03	0.34	12.5
Hispaniola	79	2.08	±0.02	0.21	9.9
Puerto Rico	30	2.38	±0.02	0.19	12.5
Virgin Islands	43	2.36	±0.03	0.25	10.6
Mexico	84	2.35	±0.02	0.26	11.1
Central America	37	2.33	±0.04	0.35	15.0
Colombia	64	2.26	±0.02	0.22	9.7
Amazon	14	2.42	±0.07	0.36	14.9
West coast of Peru and Ecuador	26	3.00	±0.05	0.35	11.7
FEMALES					
Florida	100	1,90	±0.02	0.23	8.3
Cuba	46	2.62	±0.03	0.30	11.4
Jamaica	28	2.99	±0.04	0.34	11.4
Hispaniola	74	2.23	±0.02	0.29	13.0
Puerto Rico	33	2.58	±0.03	0.25	9.7
Virgin Islands	27	2.55	±0.03	0.23	9.0
Mexico	52	2.54	±0.03	0.32	12.6
Central America	26	2.61	±0.03	0.25	9.6
Colombia	20	2.45	±0.04	0.29	11.8
Amazon	3	2.54	±0.14	0.28	11.0
West coast of Peru and Ecuador	17	3.32	±0.08	0.45	14.0

The coefficients of variation for this characteristic are of the same order as those found for measures of weight in man.

Although it is evident from the data in table 3 that there is some variation in the width of the yellow bands and that the samples from Florida and the west coast of South America south of the Rio Guayas represent the extremes, the data cannot be used to indicate narrow- and broad-banded populations since the size of the insects was not taken into consideration. Thus with populations having bands of essentially the same width as those from the Virgin Islands and Mexico it is the proportional width of the bands that makes those on the islands specimens seem broad.

To eliminate the variations in specimen size the band index was computed for each insect studied, and these indices were treated in the same manner as the direct measurements. The

mean band index for the entire collection studied is about 6.30 ± 0.30, with the males bearing bands about 0.10 less, and the females 0.15 more, than the mean. The significant limits for the band index are 2.65 to 10.05. None of the samples studied falls outside these limits. Table 4 presents the parameters of the band index for each of the populations under consideration.

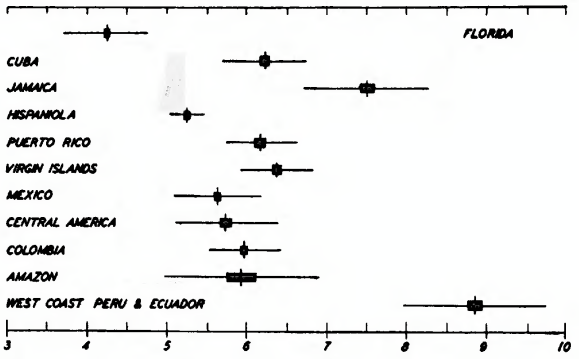

FIG. 3. Parameters of band index for males. The vertical cross line locates the mean of the sample studied, the probable error is expressed as a black block, and the standard deviation as a horizontal line.

Three populations stand apart from the others so far as the band index is concerned. These are the narrow-banded series from Florida and the wide-banded series from Jamaica and the west coast of South America. In general, table 4 shows that the band indices are a little less variable in each population than are the direct measurements.

The inter-population differences of the means are computed and stated in terms of the probable error of the difference in table 5. From the data in this table certain conclusions can be drawn about the significance of the band index as a character that sets populations apart and that may be of subspecific importance.

Although there is statistical evidence that in the great majority of cases the differences in band indices are highly significant we doubt that this is true of their taxonomic significance.

Table 5 reveals certain expected relationships and others that are not expected. The lack of definite differences in the band index among the populations from Mexico to Colombia is what might be expected where the populations have full freedom to intermingle and a gene complex may be passed from one end of

TABLE 4

BAND INDICES

Population	*N*	*M*	*P.E.*	*S.D.*	*V*
MALES					
Florida	125	4.22	±0.03	0.53	12.5
Cuba	43	6.20	±0.05	0.53	8.5
Jamaica	50	7.49	±0.08	0.78	10.4
Hispaniola	79	5.24	±0.02	0.22	4.2
Puerto Rico	30	6.17	±0.06	0.47	7.6
Virgin Islands	43	6.37	±0.05	0.45	7.1
Mexico	84	5.63	±0.04	0.55	9.8
Central America	37	5.74	±0.07	0.64	11.1
Colombia	64	5.97	±0.04	0.45	7.5
Amazon	14	5.94	±0.18	0.97	16.3
West coast of Peru and Ecuador	26	8.85	±0.12	0.88	9.9
FEMALES					
Florida	100	4.35	±0.03	0.43	9.9
Cuba	46	6.28	±0.05	0.51	8.1
Jamaica	28	7.98	±0.09	0.68	8.5
Hispaniola	74	5.42	±0.02	0.29	5.3
Puerto Rico	33	6.42	±0.04	0.36	5.6
Virgin Islands	27	6.42	±0.05	0.36	5.6
Mexico	52	5.86	±0.05	0.54	9.2
Central America	26	6.12	±0.06	0.46	7.5
Colombia	20	6.25	±0.08	0.51	8.2
Amazon	3	6.50	±0.21	0.44	6.8
West coast of Peru and Ecuador	17	9.32	±0.17	1.00	10.7

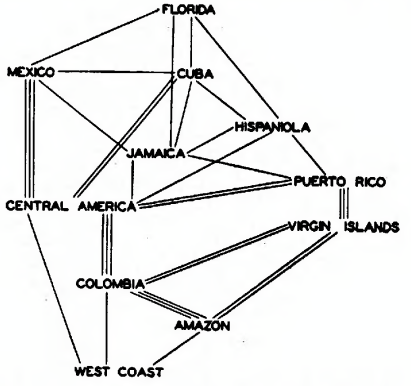

FIG. 4. Relationships of the different populations with regard to band indices. Three lines connecting two area names indicate that there is no real significance to the difference in mean size of the two samples studied. Two lines indicate some difference but of doubtful significance. One line indicates a significant difference.

TABLE 5

SIGNIFICANCE OF THE DIFFERENCES IN THE BAND INDICES

Population		F.	C.	J.	H.	P.R.	V.I.	M.	C.A.	Co.	Am.	W.C.
Florida	♂	—	33.2	36.3	25.3	x	x	28.2	x	x	x	x
	♀	—	32.2	36.3	26.8	x	x	25.2	x	x	x	x
Cuba	♂	33.2	—	14.3	19.2	x	x	9.5	5.1	x	x	x
	♀	32.2	—	17.0	17.2	x	x	6.0	2.0	x	x	x
Jamaica	♂	36.3	14.3	—	28.2	x	x	20.7	15.9	x	x	x
	♀	36.3	17.0	—	28.4	x	x	21.2	16.9	x	x	x
Hispaniola	♂	25.3	19.2	28.2	—	15.5	x	6.7	7.1	x	x	x
	♀	26.8	17.2	28.4	—	25.0	x	8.8	11.6	x	x	x
Puerto Rico	♂	x	x	x	15.5	—	2.5	7.7	4.8	x	x	x
	♀	x	x	x	25.0	—	0.0	9.3	4.3	x	x	x
Virgin Islands	♂	x	x	x	x	2.5	—	x	x	6.7	4.6	x
	♀	x	x	x	x	0.0	—	x	x	1.9	—	x
Mexico	♂	28.2	9.5	20.7	6.7	7.7	x	—	1.4	x	x	x
	♀	25.2	6.0	21.2	8.8	9.3	x	—	3.7	x	x	x
Central America	♂	x	5.1	15.9	7.1	4.8	x	1.4	—	2.9	x	20.4
	♀	x	2.0	16.9	11.6	4.3	x	3.7	—	1.3	x	17.8
Colombia	♂	x	x	x	x	x	6.7	x	2.9	—	0.6	20.1
	♀	x	x	x	x	x	1.9	x	1.3	—	—	16.1
Amazon[a]	♂	x	x	x	x	x	4.6	x	x	0.6	—	18.0
	♀	x	x	x	x	x	—	x	x	—	—	—
West coast of Peru and Ecuador[a]	♂	x	x	x	x	x	x	x	20.4	20.1	18.0	—
	♀	x	x	x	x	x	x	x	17.8	16.1	—	—

[a] These data are based on Comstock's original data, without inclusion of the material in the Brown collection.

the range to the other. Less different than the extremes of this mainland series are the samples from Puerto Rico and the Virgin Islands. They are no more different than two samples from the same population. A very curious situation exists in the Greater Antilles. There greater differences are exhibited between island populations than between any of the populations in question and the Central American population. This seems strong evidence

TABLE 6

CORRELATION BETWEEN THE LENGTH OF THE WING AND THE WIDTH OF THE BANDS

Population	*N*	*r*	*S.E.*	*r*/*S.E.*
MALES				
Florida	125	+0.63	±0.05	11.7
Cuba	43	+0.32	±0.14	2.3
Jamaica	50	+0.43	±0.11	3.8
Hispaniola	79	+0.60	±0.07	8.3
Puerto Rico	30	+0.39	±0.15	2.6
Virgin Islands	43	+0.71	±0.08	9.2
Mexico	84	+0.45	±0.09	5.2
Central America	37	+0.68	±0.09	7.6
Colombia	64	+0.57	±0.08	6.9
West coast of Peru and Ecuador	22	+0.25	±0.20	1.3
FEMALES				
Florida	100	+0.29	±0.09	3.2
Cuba	46	+0.70	±0.08	9.3
Jamaica	28	+0.58	±0.13	4.6
Hispaniola	74	+0.56	±0.08	6.9
Puerto Rico	33	+0.55	±0.12	4.5
Virgin Islands	27	+0.67	±0.11	6.4
Mexico	52	+0.65	±0.08	8.0
Central America	26	+0.61	±0.12	4.9
Colombia	20	+0.64	±0.13	4.8
West coast of Peru and Ecuador	17	+0.56	±0.17	3.4

that the Antillean populations were derived from Central America and opens up the possibility that this species invaded each island separately rather than an Antillea that ultimately broke up into the present island masses. Such a theory does not receive much support from the rest of the body of biogeography or from geology or our knowledge of the habits of *charitonius*. The marked divergence of the Floridian population from the Cuban and the other mainland populations sets it well apart and emphasizes the

importance of studying a long series of specimens from Louisiana.

The relationships between the length of the forewing and the width of the bands and with the band index were examined. Product-moment coefficients of correlation were computed for all the populations examined. The resultant data are set forth in tables 6 and 7.

TABLE 7

CORRELATION BETWEEN THE LENGTH OF THE WING AND THE BAND INDICES

Population	*N*	*r*	*S.E.*	*r/S.E.*
MALES				
Florida	125	−0.05	±0.06	0.8
Cuba	43	−0.20	±0.15	1.3
Jamaica	50	+0.02	±0.14	0.1
Hispaniola	79	−0.14	±0.12	1.2
Puerto Rico	30	−0.33	±0.16	2.0
Virgin Islands	43	−0.03	±0.15	0.2
Mexico	84	−0.10	±0.11	0.9
Central America	37	+0.03	±0.16	0.2
Colombia	64	−0.19	±0.12	1.2
West coast of Peru and Ecuador	22	−0.34	±0.19	1.8
FEMALES				
Florida	100	+0.01	±0.10	0.8
Cuba	46	−0.06	±0.15	0.4
Jamaica	28	−0.28	±0.17	1.6
Hispaniola	74	+0.28	±0.15	1.9
Puerto Rico	33	+0.49	±0.13	3.7
Virgin Islands	27	+0.18	±0.19	1.0
Mexico	52	+0.06	±0.14	0.4
Central America	26	−0.28	±0.18	1.6
Colombia	20	−0.05	±0.22	0.2
West coast of Peru and Ecuador	17	−0.15	±0.24	0.6

The quotient of *r* divided by *S.E.* is based on these data extended to the fourth decimal place and thus may differ slightly from quotients computed from the rounded figures given in table 6. This quotient must exceed 3.0 for the correlation to be significantly different from zero. No figures are given for the very small Amazonian samples, since they would have little meaning. It can be stated that in general there is a definite positive relationship between the length of the wing and the width of the band—the larger the insect the wider the band in each case.

What is said above concerning the data in table 6 applies to those in table 7. As table 6 shows that the width of the band is related to the length of the wing, table 7 shows that there is no relationship between the band index and the length of the wing. In other words, the band index is independent of the size of the insect within a given population, with one exception. The females composing the sample from Puerto Rico tend to bear bands that are proportionally wider on large specimens and pro-

TABLE 8

DEGREE TO WHICH THE SECONDARY PATTERN IS DEVELOPED

Population	*N*	Per Cent	*S.D.*	Mode
MALES				
Florida	125	40.5	2.4	2–3
Cuba	43	44.2	3.1	2–3
Jamaica	50	45.3	2.9	2–3
Hispaniola	79	40.9	2.3	2–3
Puerto Rico	30	50.6	3.7	2–3
Virgin Islands	43	72.7	2.8	4–5
Mexico	84	38.5	2.2	2
Central America	37	35.6	3.2	2
Colombia	64	35.4	2.4	2
Amazon	11	37.9	6.0	2
West coast of Peru and Ecuador	26	30.8	3.7	2
FEMALES				
Florida	100	46.2	3.4	3
Cuba	46	53.2	3.0	3–4
Jamaica	28	50.0	3.9	3
Hispaniola	74	51.8	2.4	2–3
Puerto Rico	33	72.2	3.2	4–5
Virgin Islands	27	92.3	2.2	5
Mexico	52	40.1	2.8	2–3
Central America	26	36.8	3.9	2
Colombia	20	32.5	4.3	2
Amazon	3	33.3	11.1	2
West coast of Peru and Ecuador	17	33.3	4.7	2

portionally narrower on small specimens. That is, in this case there is some evidence that the rate of increase in the width of the band is proportionally greater than the rate of increase in the length of the wing in the series studied.

The results of this statistical inquiry into the width of the bands on the forewing of *charitonius* can be stated simply: (1)

within a population the width of the yellow bands tends to vary directly with the size of the specimens; (2) each population seems to be endowed with a characteristic band index; and (3) certain populations can be recognized from all others by the band index.

THE SECONDARY PATTERN CHARACTERS

The primary pattern of this species is a series of yellow bands that cross black fasces. On the forewing there are in addition

TABLE 9

FREQUENCIES WITH WHICH EACH NUMBER OF SPOTS OCCURS

Population	*N*	0	1	2	3	4	5	6
Florida								
♂	125		4.8	53.6	35.2	6.4		
♀	100	1.0	5.0	29.0	46.0	19.0		
Cuba								
♂	43		2.3	41.9	44.2	11.6		
♀	46		10.9	19.6	28.2	28.2	6.5	6.5
Jamaica								
♂	50			46.0	38.0	14.0	2.0	
♀	28			32.2	39.3	25.0	3.6	
Hispaniola								
♂	79		3.8	51.9	39.2	5.1		
♀	74		1.3	31.1	33.8	23.0	10.8	
Puerto Rico								
♂	30			33.3	40.0	20.0	3.3	3.3
♀	33				21.2	33.3	36.4	9.1
Virgin Islands								
♂	43			2.3	16.3	32.6	39.5	9.3
♀	27				3.7	25.9	51.8	18.5
Mexico								
♂	84		2.4	70.2	23.8	2.4		1.2
♀	52		5.8	50.0	42.3	1.9		
Central America								
♂	37		10.8	73.0	13.5	2.7		
♀	26		19.3	50.0	26.9		3.8	
Colombia								
♂	64		7.8	73.5	17.2	1.6		
♀	20		20.0	65.0	15.0			
Amazon								
♂	11		9.1	63.6	18.2	9.1		
♀	3			(100.0)				
West coast of Peru and Ecuador								
♂	26		4.8	95.2				
♀	17			100.0				

TABLE 10

SIGNIFICANCE OF THE DIFFERENCES IN MACULATION

Population		F.	C.	J.	H.	P.R.	V.I.	M.	C.A.	Co.	Am.	W.C.
Florida	♂	—	1.4	1.8	0.2	x	x	0.9	x	x	x	x
	♀	—	2.3	1.1	2.0	x	x	2.0	x	x	x	x
Cuba	♂	1.4	—	0.4	1.3	x	x	2.1	2.1	x	x	x
	♀	2.3	—	1.0	0.5	x	x	4.7	5.0	x	x	x
Jamaica	♂	1.8	0.4	—	1.8	1.7	x	2.7	3.3	x	x	x
	♀	1.1	1.0	—	0.6	6.5	x	3.1	0.9	x	x	x
Hispaniola	♂	0.2	1.3	1.8	—	3.2	x	1.1	2.0	x	x	x
	♀	2.0	0.5	0.6	—	7.6	x	4.7	4.8	x	x	x
Puerto Rico	♂	x	x	1.7	3.2	—	7.1	x	4.5	x	x	x
	♀	x	x	6.5	7.6	—	7.8	x	10.4	x	x	x
Virgin Islands	♂	x	x	x	x	7.1	—	x	x	14.9	7.7	x
	♀	x	x	x	x	7.8	—	x	x	18.7	7.8	x
Mexico	♂	0.9	2.1	2.7	1.1	x	x	—	1.1	x	x	x
	♀	2.0	4.7	3.1	4.7	x	x	—	1.0	x	x	x
Central America	♂	x	2.1	3.3	2.0	4.5	x	1.1	—	0.7	x	1.5
	♀	x	5.0	0.9	4.8	10.4	x	1.0	—	1.1	x	0.9
Colombia	♂	x	x	x	x	x	14.9	x	0.7	—	0.6	1.5
	♀	x	x	x	x	x	18.7	x	1.1	—	0.1	0.2
Amazon	♂	x	x	x	x	x	7.7	x	x	0.6	—	1.5
	♀	x	x	x	x	x	7.8	x	x	0.1	—	0.0
West coast of Peru and Ecuador	♂	x	x	x	x	x	x	x	1.5	1.5	1.5	—
	♀	x	x	x	x	x	x	x	0.9	0.2	0.0	—

to the primary bands a series of yellow spots that exhibit considerable variation from specimen to specimen and possibly from population to population. These are the secondary pattern. Six of these spots have been designated A through F, and the constancy of their occurrence has been measured. These spots were defined in the original paper by Comstock and Brown.

The presence or absence of each spot was recorded for each of the specimens examined. These data were converted into per

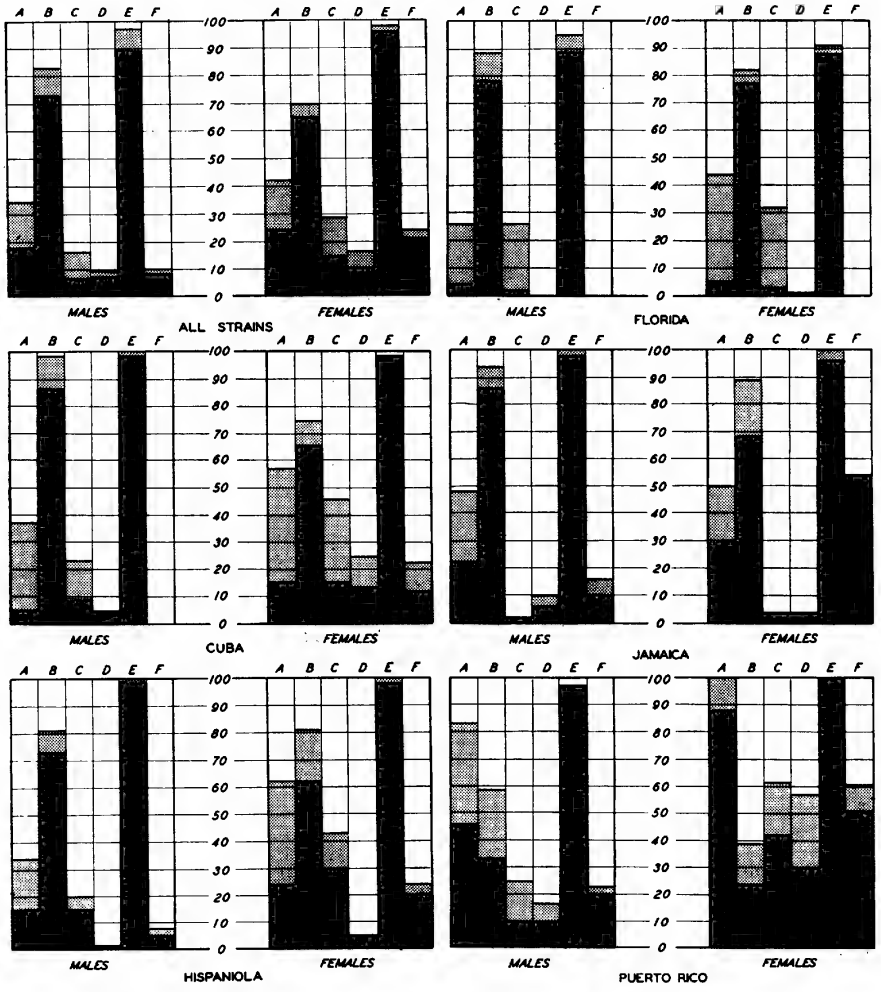

FIG. 5. Frequency of occurrence of individual spots by population. The solid bars denote the frequency with which each particular spot was found to be well developed. The stippled areas denote the frequency of "trace."

cent of occurrence for each spot in each population, and the standard deviation of the per cent was computed by the point-binomial theorem. Another easily computed statistic has been developed. This is the per cent of the total possible number of spots that occur in the secondary pattern, which is used to identify quickly those populations that are more or less maculate than their neighbors (table 8). Table 9 presents the statistical significance of the data in table 8.

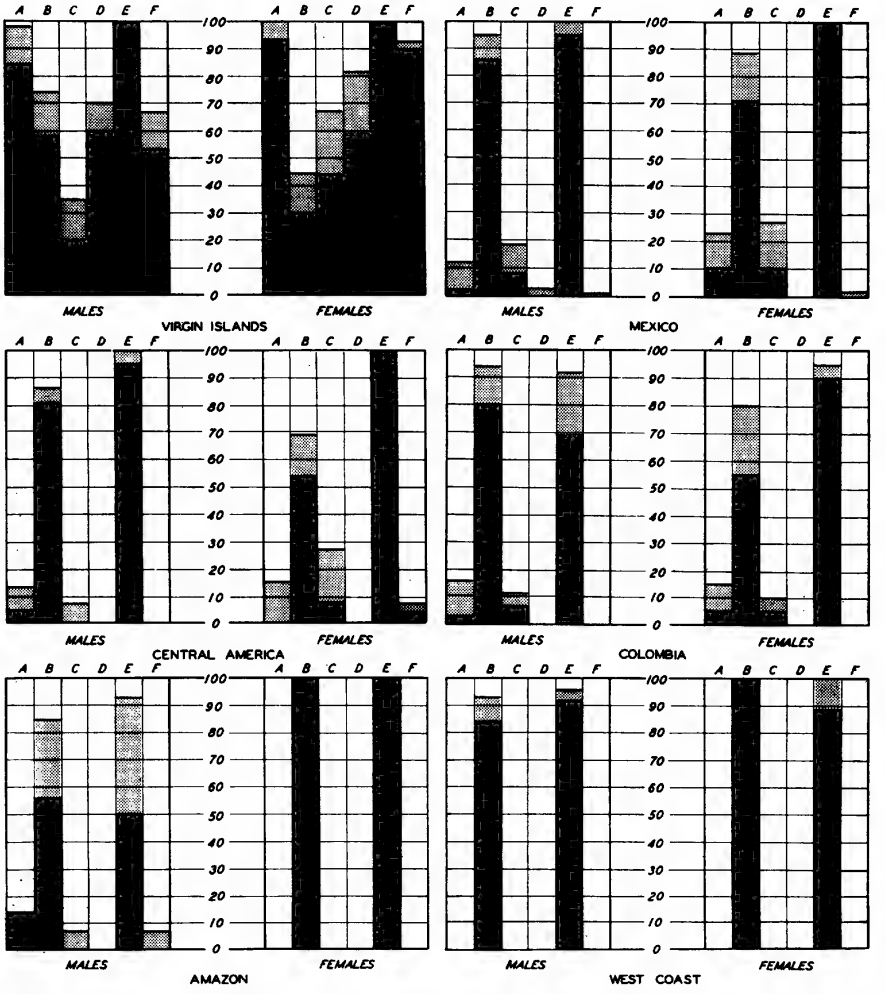

FIG. 6. Frequency of occurrence of individual spots by population. The solid bars denote the frequency with which each particular spot was found to be well developed. The stippled areas denote the frequency of "trace."

The degree of uniformity exhibited by all the mainland populations sampled is what might be expected from a species with continuous distribution. There are no significant differences

TABLE 11

FREQUENCIES WITH WHICH INDIVIDUAL SPOTS OCCUR

Population		*N*	A	B	C	D	E	F
Florida								
	♂	111	26.1	88.3	26.1	0	95.0	0
	♀	100	44.0	82.0	34.0	1.0	91.0	0
Cuba								
	♂	43	37.2	97.8	23.3	4.7	100.0	0
	♀	46	56.5	73.9	45.6	23.9	97.8	21.7
Jamaica								
	♂	50	48.0	94.0	2.0	10.0	100.0	16.0
	♀	28	50.0	89.3	3.6	3.6	100.0	53.6
Hispaniola								
	♂	79	34.2	80.9	20.3	1.3	100.0	7.6
	♀	74	62.2	81.1	43.2	5.4	100.0	24.3
Puerto Rico								
	♂	30	83.3	56.7	25.7	16.7	96.7	23.4
	♀	33	100.0	39.4	60.6	57.6	100.0	60.6
Virgin Islands								
	♂	43	97.7	74.4	34.9	69.7	100.0	67.4
	♀	27	100.0	44.4	66.6	81.4	100.0	92.6
Mexico								
	♂	84	11.9	95.2	19.0	2.4	100.0	1.2
	♀	52	23.1	88.5	26.9	0.0	100.0	1.9
Central America								
	♂	37	13.5	86.5	8.1	0.0	100.0	0.0
	♀	26	15.4	69.3	26.9	0.0	100.0	7.7
Colombia								
	♂	64	15.6	93.7	10.9	0.0	92.2	0.0
	♀	20	15.0	80.0	10.0	0.0	95.0	0.0
Amazon								
	♂	11	18.2	100.0	9.1	0.0	90.9	9.1
	♀	3	0.0	100.0	0.0	0.0	100.0	0.0
West coast of Peru and Ecuador								
	♂	22	0.0	100.0	0.0	0.0	95.5	0.0
	♀	17	0.0	100.0	0.0	0.0	100.0	0.0

between adjacent populations from Florida to South America. The Cuban, Jamaican, and Hispaniolan samples fit into this same group but with slightly greater differences. The Puerto

Rican and Virgin Islands strains stand apart as highly maculate populations. There is enough difference between these two, as far as maculation is concerned, to consider them distinct.

Tables similar to tables 9 and 10 could be constructed for each of the six spots considered, but for this study they seem to be superfluous. For those who wish to make such comparisons, the basic data are given in table 11, from which probable errors and differences can be computed.

Certain tendencies are noticeable in table 11:

Spot E occurs almost universally.

Spot B is the second most frequent to occur. Its low frequency in the Puerto Rican and Virgin Islands population, in spite of the fact that these are the most maculate, is notable.

Spot A is found in all the populations but the one from the west coast of South America south of the Rio Guayas. It occurs with significantly higher frequency in Florida and in the Antilles than it does on the mainland.

Spot C follows the same trend as spot A, with the highly significant difference that it is almost absent in the Jamaican population.

Spot F is essentially an Antillean character that occurs sparingly in Mexico, Central America, and east of the Andes.

Spot D is an Antillean character that occurs rarely in Florida and Mexico.

VARIATIONS IN COLOR

There are certain minor variations in the coloring of *charitonius*. These are associated with the yellow bands, which may be laved with rusty, black, or white scales. The frequencies with which these variants occur seem in some cases to be related to the area from which the population is drawn. One of them, "rusty," seems definitely to be sex-linked. The very low rate of occurrence for "rusty" among males may be due to faulty sexing of the specimens. Table 12 presents the data from the samples studied.

"Rusty"

An overlay of "rusty" scales on the yellow bands of the females seems to be a definite characteristic of this sex on the mainland. In the same area this character occurs in about 2 per cent of the

TABLE 12

FREQUENCIES WITH WHICH COLOR VARIATIONS OCCUR

Population	*N*	"Rusty" Per Cent	*S.D.*	"White" Per Cent	*S.D.*	"Black" Per Cent	*S.D.*
Florida							
♂	111	1.8	3.0	1.8	3.0	0.9	0.9
♀	100	44.0	5.0	3.0	1.7	2.0	1.4
Cuba							
♂	43	2.3	2.1	2.3	2.1	0.0	1.5
♀	46	8.7	4.2	0.0	1.4	2.1	2.1
Jamaica							
♂	50	2.0	2.0	0.0	1.4	0.0	1.4
♀	28	0.0	1.8	0.0	1.8	0.0	1.8
Hispaniola							
♂	79	1.3	1.2	0.0	1.1	2.5	1.9
♀	74	55.4	5.8	0.0	1.1	0.0	1.1
Puerto Rico							
♂	30	0.0	1.8	0.0	1.8	0.0	1.8
♀	33	0.0	1.7	0.0	1.7	0.0	1.7
Virgin Islands							
♂	43	2.3	2.1	0.0	1.5	0.0	1.5
♀	27	0.0	1.8	0.0	1.8	0.0	1.8
Mexico							
♂	84	2.3	1.3	0.0	1.1	0.0	1.1
♀	52	61.6	6.7	0.0	1.4	0.0	1.4
Central America							
♂	37	8.1	4.5	0.0	1.6	2.7	2.7
♀	26	65.4	9.7	0.0	1.9	0.0	1.9
Colombia							
♂	64	0.0	1.2	0.0	1.2	25.0	5.4
♀	20	60.0	11.0	0.0	2.3	0.0	2.3
Amazon							
♂	11	0.0	3.0	0.0	3.0	36.0	14.5
♀	3	33.3	27.3	0.0	5.0	33.3	27.3
West coast of Peru and Ecuador							
♂	22	0.0	2.2	0.0	2.2	45.5	10.6
♀	17	0.0	2.5	0.0	2.5	23.5	10.2

males. This may be an illusion due to faulty sexing of the specimens, or it may be that "rusty" is sex-linked with a 2 per cent cross-over rate. The Antillean situation is notable: the rate for males is essentially the same as for the males on the mainland; the rate for the females is very low, except on Hispaniola where it is as high as on the mainland.

Figure 7 shows the probable limits for the frequency with which "rusty" occurs among the mainland strains and the strains found on Hispaniola, and also that any of the populations may belong to an over-all population where the true rate for "rusty" is between 44 per cent and 56 per cent. The center point of this is 50 per cent, the theoretical frequency for the homozygous occurrence of a simple sex-linked recessive, the gene for which is present in all the females and half of the males.

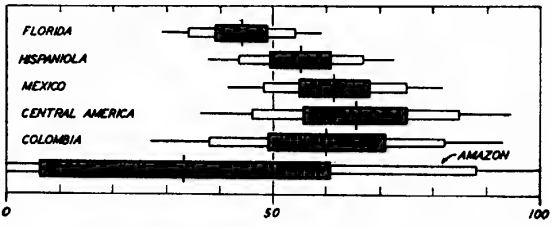

FIG. 7. The frequencies of "rusty" among females from the mainland and Hispaniola. The vertical cross line locates the frequency for rusty in the sample studied. The solid black area covers the first standard deviation each side of the mean, the open rectangle, the second, and the horizontal line, the third.

"WHITE"

The restriction of "white" to the adjacent populations on Cuba and Florida and the low frequency with which it occurs suggest that it is a recently acquired character and that it is probably recessive. The only other sample in which "white" occurs is the totally inadequate series that represent the species from Venezuela.

"BLACK"

Although "black" is absent from three of the Antillean and the Mexican samples studied, there is no assurance that it is absent from these populations. On the basis of the theory of sampling limits and the material studied, the fundamental frequency for "black" outside South America may be anything up to 1.4 per cent. If the true frequency is of this order outside South America, it is to be expected that "black" would appear in only one-half of the 100-specimen samples examined. Since only the Floridian samples are of this size and all the others are less numerous, the absence of "black" among the specimens from Jamaica, Puerto

Rico, the Virgin Islands, and Mexico may have no meaning.

The very great difference between the frequencies found among the samples from South America and those studied from outside that area is significant. It is highly probable that the real frequency for "black" in South America lies between 15 per cent and 50 per cent. The absence of a single black specimen among the 20 Colombian females is of no significance, since in so small a sample a character may be absent, although the true frequency for the population is as high as 30 per cent.

"White Band"

There occur on specimens from the Pacific slope of Peru and southern Ecuador several variations not found on any specimen of other populations studied. Among these is a white band instead of a yellow band across the apex of the forewing, a phenomenon normal in this population. However, in about 10 per cent of the males and 5 per cent of the females this normally white band is yellow, as it is in all the other populations studied. Very rarely all the bands are white in color among the specimens from Florida.

"White Tip"

Another color modification found on the Pacific slope strains in Peru and southern Ecuador is white tips on the yellow bands. In the small sample studied this was observed only on females where the frequency found was 23.5 per cent.

THE FLORIDIAN STRAIN, *HELICONIUS CHARITONIUS TUCKERI* COMSTOCK AND BROWN

The Sample

The Floridian population is represented in this study by 125 males and 100 females. Statistically this may be considered an adequate sample. Geographically the sample is lacking in specimens from the northwestern part of the range. It is not known how far westward along the Gulf Coast the characters exhibited by the Floridian strain hold true. The seasonal distribution of the sample is probably fairly representative of the seasonal abundance of the species in Florida.

PARAMETERS

CENTRAL TENDENCIES: MALES

Length of forewing	41.82 ± 0.24 mm.	*S.D.* = 3.96 mm.	*V* = 9.5
Width of band	1.75 ± 0.02 mm.	*S.D.* = 0.27 mm.	*V* = 15.2
Band index	4.22 ± 0.03%	*S.D.* = 0.53%	*V* = 12.5

CENTRAL TENDENCIES: FEMALES

Length of forewing	42.43 ± 0.24 mm.	*S.D.* = 3.58 mm.	*V* = 8.5
Width of band	1.90 ± 0.02 mm.	*S.D.* = 0.23 mm.	*V* = 12.1
Band index	4.35 ± 0.03%	*S.D.* = 0.43%	*V* = 9.8

COEFFICIENTS OF CORRELATION

Males		
Length of forewing vs. width of band	$r = +0.6320$	*S.E.* = 0.0537
Length of forewing vs. band index	$r = -0.0534$	*S.E.* = 0.0640
Females		
Length of forewing vs. width of band	$r = +0.2901$	*S.E.* = 0.0916
Length of forewing vs. band index	$r = +0.0085$	*S.E.* = 0.1000

PATTERN AND COLOR FREQUENCIES

	Males	Females
A	26.1 ± 4.2[a]	44.0 ± 5.0
B	88.3 ± 3.1	82.0 ± 3.8
C	26.1 ± 4.2	34.0 ± 4.7
D	0.0 ± 0.9	1.0 ± 1.0
E	95.0 ± 2.1	91.0 ± 2.8
F	0.0 ± 0.9	0.0 ± 0.9
"Broken"	84.7 ± 3.4	80.0 ± 4.0
"Rusty"	1.8 ± 1.3	44.0 ± 5.0
"White"	1.8 ± 1.3	3.0 ± 1.7
"Black"	1.1 ± 1.1	2.0 ± 1.4

[a] The error is expressed as plus or minus the standard deviation converted to per cent.

COMPARISON WITH ADJACENT STRAINS

The geographic position of Florida dictates comparison of this strain with the populations found on Cuba and in Mexico. Certain similarities in the minor details of variation require the Floridian and Hispaniolan strains to be compared critically. Although there is little probability of a past land bridge between these areas, and the bypassing of Cuba, there is a possibility that such existed.

SIZE: The Floridian sample shows no significant differences in either sex from the Cuban or Mexican samples. With respect to the Hispaniolan sample the difference is sufficient to be considered statistically significant. Since the samples, large as they are, really represent an insignificant fraction of the populations sampled we are loath to accept a difference only three times its probable error as being of taxonomic significance. Under such conditions as prevail in taxonomy we prefer to recognize only such differences as are seven times or more their probable errors. Thus the difference between the Floridian and Hispaniolan strains does not qualify as a biological difference.

BAND INDEX: The Floridian sample is composed of individuals bearing the narrowest bands of all of the samples studied. All three adjacent populations differ from the Floridian sample enough to be considered biologically different. The least different pair (Florida-Hispaniola) has a quotient 25.2. The chance that this might arise between two samples drawn from the same population is so small that we may almost assume it to be impossible. We suggest that the broad-banded January male from Miami in dos Passos' collection is a stray from Cuba.

MACULATION: The Floridian specimens differ from all others in the character described by Comstock as "broken." In many other populations the outline of this transverse band is irregular, but in no other is it so clearly and persistently notched.

The degree to which the secondary yellow spots are developed on the Floridian sample is not significantly different from the samples from Cuba, Mexico, or Hispaniola. The distribution of the spots on the Floridian sample seems to differ from that on the two Antillean samples, and this may be of some significance. Spot F appears on about one-quarter of the females from the islands but on none of them from Florida. The other four spots show no real differences in frequency among the four samples.

COLOR: The Floridian sample differs strongly from the Cuban so far as "rusty" is concerned, but it is like the Cuban in regard to "white" and "black." The Floridian, Mexican, and Hispaniolan strains are more or less alike for "rusty" but differ in frequencies for "white" and "black." We put no reliance on "white" or "black" differences except among South American strains.

Conclusions

The narrow yellow bands set the Floridian strain apart from all others when large series are examined together. This segregation is supported by other minor differences from adjacent populations.

The Cuban Strain, *Heliconius charitonius ramsdeni* Comstock and Brown

The Sample

Forty-three males and 46 females from the Cuban population have been studied. These samples are just adequate from the statistical point of view. The geographic distribution of the specimens leaves much to be desired. Fully two-thirds of the sample came from the eastern province of Oriente. A comparison of this large eastern sub-sample with the smaller one from the rest of Cuba reveals no significant reason for questioning the pooling of all Cuban specimens. No material was examined from the Isle of Pines nor the Caymans, two areas usually showing very close affinity with Cuban material. The species is unknown in the Bahamas.

Parameters

Central Tendencies: Males

Length of forewing	41.09 ± 0.33 mm.	*S.D.* = 3.18 mm.	*V* = 7.7
Width of band	2.54 ± 0.03 mm.	*S.D.* = 0.27 mm.	*V* = 10.6
Band index	6.20 ± 0.05%	*S.D.* = 0.53%	*V* = 8.5

Central Tendencies: Females

Length of forewing	41.76 ± 0.35 mm.	*S.D.* = 3.51 mm.	*V* = 8.4
Width of band	2.62 ± 0.03 mm.	*S.D.* = 0.30 mm.	*V* = 11.4
Band index	6.28 ± 0.05%	*S.D.* = 0.51%	*V* = 8.1

Coefficients of Correlation

Males		
Length of forewing vs. width of band	$r = +0.3174$	*S.E.* = 0.1371
Length of forewing vs. band index	$r = -0.1966$	*S.E.* = 0.1466
Females		
Length of forewing vs. width of band	$r = +0.7009$	*S.E.* = 0.0750
Length of forewing vs. band index	$r = -0.0610$	*S.E.* = 0.1469

PATTERN AND COLOR FREQUENCIES

	Males	Females
A	37.2 ± 7.4	56.5 ± 7.2
B	97.8 ± 2.6	73.9 ± 6.5
C	23.3 ± 6.5	45.6 ± 7.2
D	4.7 ± 3.3	23.9 ± 6.3
E	100.0 ± 1.4	97.8 ± 2.4
F	0.0 ± 1.4	21.7 ± 6.1
"Ragged"	2.3 ± 2.3	4.3 ± 3.0
"Rusty"	2.3 ± 2.3	8.7 ± 4.1
"White"	2.3 ± 2.3	0.0 ± 1.3
"Black"	0.0 ± 1.4	2.1 ± 2.2

COMPARISON WITH ADJACENT STRAINS

The populations in Florida, Mexico, Central America, Jamaica, and Hispaniola are so situated that each or any may have contributed to the current population on Cuba. It has already been demonstrated that the Floridian strain may be considered distinct from the Cuban.

SIZE: So far as size is concerned all the populations mentioned above except the one on Jamaica might be considered parts of a single super-population. Both sexes from Jamaica are so much smaller than their counterparts in the Cuban population that there is less chance than one in a billion that they are samples drawn from a single population. The females from Mexico studied are larger than those from Cuba. This difference approaches real significance.

BAND INDEX: The proportional width of the yellow bands on the Cuban specimens is intermediate to the ratios found on the surrounding populations. Little or no significance can be placed on the difference observed between the Central American and Cuban samples. The Mexican and Hispaniolan samples bear narrower bands than the Cuban. These populations show differences from the Cuban that approach significance. However, the difference is not of the order that separates the Cuban and Floridian strains. The Jamaican strain bears materially wider bands than the strain found on Cuba. This difference is of biological significance.

MACULATION: The character "broken" does not occur in Cuba. In its stead occasional specimens show a rather ragged outline to the band in question. This same condition occurs sparingly among the samples from Hispaniola and Jamaica but has not been observed on Mexican or Central American specimens.

The secondary pattern of yellow spots on the forewing is developed to about the same degree on the Cuban, Jamaican, and Hispaniolan strains. The Mexican and Central American strains show a little less development than does the Cuban. We doubt that there is any significance to these differences. There seems to be some difference between strains in the frequency with which certain spots are present:

Spot A. Mexican and Central American specimens of both sexes show this spot significantly less often than do Cuban specimens.

Spot C. This spot appears less often on Central American and Mexican specimens than on Cuban specimens, but the differences are of doubtful significance. Among the Cuban and Jamaican females there is a definitely significant difference, the spot appearing only occasionally on Jamaican specimens.

Spot D. This spot shows no significant differences among the males of the strains being discussed, but the females of Cuba show it significantly more often than the females of any of the other strains.

Spot F. Cuban specimens of both sexes show this spot with significantly less frequency than do the Jamaican specimens. On Mexican females it appears significantly less frequently than on Cuban females.

In spite of all of this, only spots A and C appear frequently enough on Cuban specimens to be considered part of the secondary pattern, and then only on the females.

COLOR: The frequency with which "rusty" appears on Cuban females is very significantly less than is found among the females from Florida, Mexico, Central America, or Hispaniola. There is no significance to the difference found between Cuban and Jamaican females. The frequency for "rusty" on Cuban males is not different from that found on other strains. No reliance can be placed on the difference for "white" or "black" among the strains studied.

CONCLUSIONS

The Cuban strain seems to differ sufficiently from the narrow-banded Floridian strain and the broad-banded Jamaican strain for the differences to be taxonomically important. The differences between the Cuban and the Middle American and Hispaniolan strains are often statistically valid, but their biological

importance is open to question. The low frequency of "rusty" among Cuban females seems to us to be the only support afforded by this study of a limited number of variables for taxonomic separation of the population of Cuba from that in Middle America and on Hispaniola.

THE JAMAICAN STRAIN, *HELICONIUS CHARITONIUS SIMULATOR* ROEBER

The Sample

There are 50 males and 28 females in the sample studied. The number of males is adequate, but that of the females is not. Only the central portion of the island is well represented. There are no specimens from the northeastern and southwestern portions of the island. However, it is not likely that there is any marked local variation on the island of Jamaica.

Parameters

Central Tendencies: Males

Length of forewing	36.32 ± 0.24 mm.	*S.D.* = 2.52 mm.	*V* = 6.9
Width of band	2.72 ± 0.03 mm.	*S.D.* = 0.34 mm.	*V* = 12.5
Band index	7.49 ± 0.08%	*S.D.* = 0.78 %	*V* = 10.4

Central Tendencies: Females

Length of forewing	37.47 ± 0.27 mm.	*S.D.* = 2.09 mm.	*V* = 5.6
Width of band	2.99 ± 0.04 mm.	*S.D.* = 0.34 mm.	*V* = 11.4
Band index	7.98 ± 0.09%	*S.D.* = 0.68%	*V* = 8.5

Coefficients of Correlation

Males		
Length of forewing vs. width of band	*r* = +0.4337	*S.E.* = 0.1148
Length of forewing vs. band index	*r* = +0.0150	*S.E.* = 0.1410
Females		
Length of forewing vs. width of band	*r* = +0.5770	*S.E.* = 0.1260
Length of forewing vs. band index	*r* = −0.2790	*S.E.* = 0.1730

Pattern and Color Frequencies

	Males	Females
A	48.0 ± 7.0	50.0 ± 9.3
B	94.0 ± 3.4	89.3 ± 5.7
C	2.0 ± 2.0	3.6 ± 3.5
D	10.0 ± 4.2	3.6 ± 3.5
E	100.0 ± 1.4	100.0 ± 1.8
F	16.0 ± 5.2	53.6 ± 9.3
"Ragged"	0.0 ± 1.4	0.0 ± 1.8
"Rusty"	2.0 ± 2.0	0.0 ± 1.8
"White"	0.0 ± 1.4	0.0 ± 1.8
"Black"	0.0 ± 1.4	0.0 ± 1.8

Comparison with Adjacent Strains

The strains that surround Jamaica are those from Cuba, Hispaniola, Mexico, and Central America. There is considerable evidence that Jamaica once formed part of a land bridge that connected Honduras with a land mass that has since broken up to form the Greater Antilles. As is developed in the following paragraphs the *charitonius* population on Jamaica differs so markedly from the populations of surrounding areas as to suggest that it has been longer isolated from the mainland than either the Cuban or Hispaniolan population. This seems contrary to most geological and biological evidence thus far set forth. For this species Barbour's Yucatecan bridge is more satisfactory than Schuchert's Honduran bridge. We do not believe that Matthew's contention that the Antillean fauna is a waif fauna is tenable on the basis of our present knowledge of the behavior of the current fauna.

Size: The Jamaican strain is significantly smaller, statistically and biologically, than any of the surrounding populations.

Band Index: The Jamaican strain bears bands that are actually and proportionally broader than those found on surrounding strains. These differences are in each case significant.

Maculation: The degree to which the secondary pattern is developed on the forewing of Jamaican specimens is not significantly different from that on either the Cuban or Hispaniolan strains. The differences found between the Jamaican and the adjacent mainland strains is a little greater and approaches significance.

The frequencies for the various individual spots shows that the Jamaican strain differs strongly from the adjacent mainland strains for spot A; from Mexican, Cuban, Hispaniolan, and possibly Central American strains for spot C; and from all but the Hispaniolan strain for spot F.

Color: The Jamaican strain agrees with the Cuban but differs from the others with which it is being compared in regard to the frequency of "rusty."

Conclusion

The Jamaican strain stands out more clearly than any other Antillean population as being worthy of taxonomic recognition.

THE HISPANIOLAN STRAINS, *HELICONIUS CHARITONIUS CHURCHI* COMSTOCK AND BROWN

The Sample

The paleogeography of Hispaniola is such that it was felt wise to divide the material available into two principal groups: those specimens principally from the southwestern part of the island and those principally from the northeastern part. For convenience the former is called the Haitian sample and the latter the Dominican. In neither case does the sample adequately represent the national area for which it is named. So far as numbers go the Haitian sample is adequate for both sexes (55 males and 58 females). The Dominican sample is not adequate (24 males and 16 females). For the island of Hispaniola the sample may be considered statistically adequate (79 males and 74 females) but geographically not well distributed.

Parameters

	Central Tendencies: Males		
Length of forewing			
Haitian	39.53 ± 0.30 mm.	*S.D.* = 3.34 mm.	*V* = 8.2
Dominican	40.50 ± 0.32 mm.	*S.D.* = 2.27 mm.	*V* = 5.6
Hispaniolan	39.83 ± 0.24 mm.	*S.D.* = 3.17 mm.	*V* = 8.0
Width on band			
Haitian	2.07 ± 0.02 mm.	*S.D.* = 0.23 mm.	*V* = 10.6
Dominican	2.10 ± 0.03 mm.	*S.D.* = 0.19 mm.	*V* = 9.0
Hispaniolan	2.08 ± 0.02 mm.	*S.D.* = 0.21 mm.	*V* = 9.9
Band index			
Haitian	5.26 ± 0.04%	*S.D.* = 0.45%	*V* = 8.6
Dominican	5.19 ± 0.06%	*S.D.* = 0.39%	*V* = 7.5
Hispaniolan	5.24 ± 0.02%	*S.D.* = 0.22%	*V* = 4.2
	Central Tendencies: Females		
Length of forewing			
Haitian	40.40 ± 0.24 mm.	*S.D.* = 2.64 mm.	*V* = 6.5
Dominican	43.26 ± 0.55 mm.	*S.D.* = 3.15 mm.	*V* = 7.3
Hispaniolan	41.02 ± 0.24 mm.	*S.D.* = 3.00 mm.	*V* = 5.9
Width of band			
Haitian	2.22 ± 0.02 mm.	*S.D.* = 0.27 mm.	*V* = 12.2
Dominican	2.28 ± 0.03 mm.	*S.D.* = 0.34 mm.	*V* = 14.9
Hispaniolan	2.23 ± 0.02 mm.	*S.D.* = 0.29 mm.	*V* = 13.0
Band index			
Haitian	5.45 ± 0.05%	*S.D.* = 0.56%	*V* = 10.3
Dominican	5.30 ± 0.12%	*S.D.* = 0.67%	*V* = 12.6
Hispaniolan	5.42 ± 0.02%	*S.D.* = 0.29%	*V* = 5.3

COEFFICIENT OF CORRELATION: MALES

Length of forewing vs. width of band		
Haitian	$r = +0.6307$	$S.E. = 0.0812$
Dominican	$r = +0.6846$	$S.E. = 0.1085$
Length of forewing vs. band index		
Haitian	$r = -0.1553$	$S.E. = 0.1316$
Dominican	$r = -0.1612$	$S.E. = 0.1988$

COEFFICIENT OF CORRELATION: FEMALES

Length of forewing vs. width of band		
Haitian	$r = +0.5531$	$S.E. = 0.1042$
Dominican	$r = +0.6141$	$S.E. = 0.1570$
Length of forewing vs. band index		
Haitian	$r = +0.4881$	$S.E. = 0.1309$
Dominican	$r = +0.2354$	$S.E. = 0.2361$

PATTERN AND COLOR FREQUENCIES: MALES

	Haitian	Dominican	Hispaniolan
A	32.7 ± 6.4	37.5 ± 10.0	34.2 ± 5.3
B	81.7 ± 5.3	79.2 ± 8.3	80.9 ± 4.4
C	23.6 ± 5.5	12.5 ± 6.7	20.3 ± 4.5
D	1.8 ± 1.8	0.0 ± 2.1	1.3 ± 1.3
E	100.0 ± 1.2	100.0 ± 2.1	100.0 ± 1.1
F	9.1 ± 3.8	4.2 ± 4.2	7.6 ± 3.0
"Ragged"	0.0 ± 1.2	4.2 ± 4.2	1.3 ± 1.3
"Rusty"	1.8 ± 1.8	0.0 ± 2.1	1.3 ± 1.3
"White"	0.0 ± 1.2	0.0 ± 2.1	0.0 ± 1.1
"Black"	0.0 ± 1.2	8.3 ± 5.4	2.5 ± 1.5

PATTERN AND COLOR FREQUENCIES: FEMALES

A	62.1 ± 6.4	62.5 ± 11.9	62.2 ± 5.7
B	77.5 ± 5.3	93.7 ± 6.3	81.1 ± 4.6
C	39.6 ± 6.4	56.2 ± 12.5	43.2 ± 5.8
D	1.7 ± 1.7	18.7 ± 10.0	5.4 ± 2.7
E	100.0 ± 1.3	100.0 ± 2.5	100.0 ± 1.1
F	27.5 ± 5.9	12.5 ± 8.1	24.3 ± 5.0
"Ragged"	1.7 ± 1.7	0.0 ± 2.5	1.3 ± 1.3
"Rusty"	44.8 ± 6.5	93.7 ± 6.3	55.4 ± 5.8
"White"	0.0 ± 1.3	0.0 ± 2.5	0.0 ± 1.1
"Black"	0.0 ± 1.3	0.0 ± 2.5	0.0 ± 1.1

COMPARISON OF HAITIAN AND DOMINICAN STRAINS

No significance can be attached to the differences found between the measurements and the band indices set forth for these strains. The nearest approach to a significant difference is found in the greater size of the Dominican females. This sample is so small that we feel sure a larger sample will make this apparent difference much less evident. While some of the minor pattern

differences approach statistical significance, the small size of the Dominican sample casts doubt on any biological validity. The difference between the frequencies with which "rusty" appears on the females may be a real difference between the two strains. This is not so of "black" among the males. With only "rusty" significantly different between the two strains, we believe it safe to consider the two as sub-populations of a single Hispaniolan population for comparison with the populations on adjacent islands and the mainland.

Comparison with Adjacent Strains

The geographic neighbors of the Hispaniolan strain are from Cuba, Jamaica, and Puerto Rico. Because of certain paleogeographic suggestions, comparison is made also with the material from Middle America. Previously the Hispaniolan strain has been demonstrated to be different from the Floridian and Jamaican strains. While a difference does exist between the material from Cuba and Hispaniola, it is only the high frequency of "rusty" on Hispaniola that suggests that the Hispaniolan strain is different from the Cuban. This leaves the Central American, Mexican, and Puerto Rican populations to be compared with the Hispaniolan

Size: The material from Hispaniola does not differ significantly from that studied from Puerto Rico or Central America. The difference from the Mexican sample approaches significance.

Band Index: From a purely statistical point of view the band index of each sex of the Hispaniolan strains is significantly different from the surrounding strains. This is particularly true for the Cuban, Puerto Rican, and Jamaican samples and much less so for the samples from Middle America. In spite of these clear-cut statistical differences we doubt if they can be used taxonomically. In general appearance the bands on the Hispaniolan material are intermediate to the Floridian strain on the one hand and the Cuban and Puerto Rican on the other.

Maculation: The degree to which the secondary pattern is developed on the forewings of the Hispaniolan strain differs from the other strains only in the case of the females from Puerto Rico.

In regard to specific spots there are some differences that seem to be significant:

Spot A seems to be a characteristic part of the pattern of the

Puerto Rican strain and definitely not of either the Hispaniolan or its Dominican fraction.

Spot B is normal in its frequency on the Hispaniolan strain and appears often enough to be considered a regular part of the pattern. This is not true of the Puerto Rican females.

Spots D and F, as is also true of A, are significantly less often found on the Hispaniolan strain than on the Puerto Rican.

In relation to the Middle American samples spots A and F occur with significantly higher frequencies on the Hispaniolan specimens than on either the Mexican or Central American material.

COLOR: The Hispaniolan strain is the only one in the Antilles where "rusty" occurs commonly. In this respect the strain is like the strains from the mainland.

CONCLUSIONS

The Hispaniolan strain is definitely different from the Jamaican strain. It is less distinct from the Puerto Rican strain and still less from the Cuban. The differences from the Middle American strains may be significant. The lower band index plus the high frequency for "rusty" in the females may set the Hispaniolan material apart from the Cuban, but we question it.

THE PUERTO RICAN STRAIN, *HELICONIUS CHARITONIUS CHARITONIUS* (LINNAEUS)

THE SAMPLE

The series studied from this island is barely adequate from the statistical point of view. There are only 30 males and 33 females in it. The majority of the specimens were taken in the northwestern and north central parts of the island. The southwestern, central, and east central areas are not represented. A better distribution of specimens could be desired, but there seems to be no reason against considering the population homogeneous.

PARAMETERS

	CENTRAL TENDENCIES: MALES		
Length of forewing	38.68 ± 0.28 mm.	*S.D.* = 2.27 mm.	*V* = 5.9
Width of band	2.38 ± 0.02 mm.	*S.D.* = 0.19 mm.	*V* = 12.5
Band index	6.17 ± 0.06%	*S.D.* = 0.47%	*V* = 7.6
	CENTRAL TENDENCIES: FEMALES		
Length of forewing	40.16 ± 0.29 mm.	*S.D.* = 2.45 mm.	*V* = 6.1
Width of band	2.58 ± 0.03 mm.	*S.D.* = 0.25 mm.	*V* = 9.7
Band index	6.42 ± 0.04%	*S.D.* = 0.36%	*V* = 5.6

COEFFICIENTS OF CORRELATION

Males		
Length of forewing vs. width of band	$r = +0.3948$	$S.E. = 0.1534$
Length of forewing vs. band index	$r = -0.3277$	$S.E. = 0.1630$
Females		
Length of forewing vs. width of band	$r = +0.5481$	$S.E. = 0.1218$
Length of forewing vs. band index	$r = +0.4864$	$S.E. = 0.1329$

PATTERN AND COLOR FREQUENCIES

	Males	Females
A	83.3 ± 6.7	100.0 ± 1.5
B	56.7 ± 9.0	39.4 ± 8.5
C	25.6 ± 8.0	60.6 ± 8.5
D	16.7 ± 6.7	57.6 ± 8.5
E	96.7 ± 3.3	100.0 ± 1.5
F	23.4 ± 7.7	60.6 ± 8.5
"Ragged"	0.0 ± 1.7	0.0 ± 1.5
"Rusty"	0.0 ± 1.7	0.0 ± 1.5
"White"	0.0 ± 1.7	0.0 ± 1.5
"Black"	0.0 ± 1.7	0.0 ± 1.5

Of all of the samples analyzed only the Puerto Rican females show a coefficient of correlation that differs from zero for the size-band index factors. Since this relationship is positive it means that the width of the band increases more rapidly than does the size of the insect. A similar situation is approached among the females from the eastern part of Hispaniola, adjacent to Puerto Rico.

COMPARISON WITH ADJACENT STRAINS

Our present knowledge of the paleogeography of the region under consideration suggests that when the Puerto Rican strain is compared with the strain from the Virgin Islands and that from Hispaniola there should be a closer agreement between the Puerto Rican material and the Virgin Islands series than between this material and the Hispaniolan, and that there should be a much closer agreement between the Puerto Rican and Dominican sub-sample than between the Puerto Rican and Haitian sub-sample. This seems to be essentially true only so far as pattern is concerned.

SIZE: The Puerto Rican strain is intermediate to the two adjacent ones. It is larger than the Virgin Islands and smaller than the Hispaniolan strains. In no case is the difference significant.

BAND INDEX: The proportional width of the bands on the Puerto Rican strain does not differ statistically from that found for the Virgin Islands strain. The Hispaniolan strains bear bands that are significantly narrower than those found on the Puerto Rican strain. Whether this is of taxonomic value is questionable.

MACULATION: The Puerto Rican and Virgin Islands samples are the most maculate of all the samples studied. The degree to which the spots are developed on the Puerto Rican strain is significantly different from the Virgin Islands males and from both the Virgin Islands and Hispaniolan females.

The Puerto Rican and Virgin Islands strains differ from all others in the high frequency for spots A, C, D, and F. They are the only samples with relatively low frequencies for spot B. The difference between the two strains lies in the significantly higher frequency for spots D and F on the Virgin Islands specimens.

COLOR: Secondary color variation is absent in the Puerto Rican sample. In this the sample differs from all others seen. However, it is of very doubtful importance since the sample is quite small.

CONCLUSIONS

The Puerto Rican strain appears to be significantly different from all other samples studied except the strain from the Virgin Islands.

THE VIRGIN ISLANDS STRAINS, *HELICONIUS CHARITONIUS CHARITONIUS* (LINNAEUS)

THE SAMPLE

The Virgin Islands sample is an accumulation of short series from St. Thomas, St. John, St. Croix, and Tortola. It is most unfortunate that there was no series from St. Kitts available for study and possible inclusion with these. St. Kitts is the type locality of *H. charitonius punctata* Hall.

A total of 43 males and 27 females were examined. Thus statistically the male fraction can be considered as reasonably adequate, but the female fraction not so. Of the series studied only the series from St. Croix approaches being an adequate sample of the island's population. As can be seen from the follow-

ing parameters, pooling the data from the four islands as a single strain is defensible.

PARAMETERS

CENTRAL TENDENCIES: MALES

	N			
Length of forewing				
St. Thomas	9	37.49 ± 0.50 mm.	*S.D.* = 2.09 mm.	*V* = 5.6
St. John	3	39.50 ± 0.86 mm.	*S.D.* = 1.80 mm.	*V* = 4.6
Tortola	2	36.45 ± 2.05 mm.	*S.D.* = 3.04 mm.	*V* = 8.3
St. Croix	29	38.14 ± 0.35 mm.	*S.D.* = 2.73 mm.	*V* = 7.2
Virgin Islands	43	38.02 ± 0.26 mm.	*S.D.* = 2.53 mm.	*V* = 6.8
Width of band				
St. Thomas	9	2.48 ± 0.06 mm.	*S.D.* = 0.24 mm.	*V* = 9.7
St. John	3	2.40 ± 0.05 mm.	*S.D.* = 0.10 mm.	*V* = 4.2
Tortola	2	2.30 ± 0.30 mm.	*S.D.* = 0.44 mm.	*V* = 19.1
St. Croix	29	2.42 ± 0.03 mm.	*S.D.* = 0.27 mm.	*V* = 11.1
Virgin Islands	43	2.42 ± 0.03 mm.	*S.D.* = 0.25 mm.	*V* = 10.3
Band index				
St. Thomas	9	6.60 ± 0.11%	*S.D.* = 0.46%	*V* = 7.0
St. John	3	6.07 ± 0.04%	*S.D.* = 0.11%	*V* = 1.8
Tortola	2	6.25 ± 0.43%	*S.D.* = 0.64%	*V* = 10.3
St. Croix	29	6.33 ± 0.06%	*S.D.* = 0.45%	*V* = 7.1
Virgin Islands	43	6.37 ± 0.05%	*S.D.* = 0.45%	*V* = 7.1

CENTRAL TENDENCIES: FEMALES

Length of forewing				
St. John	9	39.16 ± 0.61 mm.	*S.D.* = 2.57 mm.	*V* = 6.6
St. Croix	18	39.94 ± 0.38 mm.	*S.D.* = 2.31 mm.	*V* = 5.8
Virgin Islands	27	39.69 ± 0.33 mm.	*S.D.* = 2.51 mm.	*V* = 6.3
Width of band				
St. John	9	2.48 ± 0.06 mm.	*S.D.* = 0.23 mm.	*V* = 9.1
St. Croix	18	2.56 ± 0.04 mm.	*S.D.* = 0.23 mm.	*V* = 9.0
Virgin Islands	27	2.55 ± 0.03 mm.	*S.D.* = 0.23 mm.	*V* = 9.0
Band index				
St. John	9	6.47 ± 0.09%	*S.D.* = 0.37%	*V* = 5.7
St. Croix	18	6.40 ± 0.06%	*S.D.* = 0.36%	*V* = 5.6
Virgin Islands	27	6.42 ± 0.05%	*S.D.* = 0.36%	*V* = 5.6

COEFFICIENTS OF CORRELATION

Males		
Length of forewing vs. width of band	$r = +0.7068$	*S.E.* = 0.0763
Length of forewing vs. band index	$r = -0.0304$	*S.E.* = 0.1524
Females		
Length of forewing vs. width of band	$r = +0.6742$	*S.E.* = 0.1050
Length of forewing vs. band index	$r = +0.1807$	*S.E.* = 0.1862

PATTERN AND COLOR FREQUENCIES: MALES

	St. Thomas	St. Croix	Virgin Islands
A	100.0 ± 9.5	100.0 ± 3.1	97.7 ± 2.3
B	44.4 ± 16.7	82.8 ± 7.2	74.4 ± 6.7
C	77.7 ± 13.3	24.2 ± 7.9	34.9 ± 7.2
D	77.7 ± 13.3	72.4 ± 7.9	69.7 ± 7.0
E	100.0 ± 9.5	100.0 ± 3.1	100.0 ± 2.1
F	55.5 ± 16.7	69.0 ± 8.6	67.4 ± 7.2
"Ragged"	0.0 ± 9.5	0.0 ± 3.1	0.0 ± 2.1
"Rusty"	0.0 ± 9.5	3.4 ± 3.1	2.3 ± 2.3
"White"	0.0 ± 9.5	0.0 ± 3.1	0.0 ± 2.1
"Black"	0.0 ± 9.5	0.0 ± 3.1	0.0 ± 2.1

PATTERN AND COLOR FREQUENCIES: FEMALES

	St. John	St. Croix	Virgin Islands
A	100.0 ± 9.5	100.0 ± 5.0	100.0 ± 3.9
B	22.2 ± 13.3	55.6 ± 11.7	44.4 ± 9.6
C	77.8 ± 13.3	61.1 ± 11.1	66.7 ± 8.9
D	77.8 ± 13.3	83.3 ± 8.9	81.4 ± 7.4
E	100.0 ± 9.5	100.0 ± 5.0	100.0 ± 3.9
F	88.9 ± 10.0	94.4 ± 5.0	92.6 ± 5.2
"Ragged"	0.0 ± 9.5	0.0 ± 5.0	0.0 ± 3.9
"Rusty"	0.0 ± 9.5	0.0 ± 5.0	0.0 ± 3.9
"White"	0.0 ± 9.5	5.6 ± 5.0	3.9 ± 3.7
"Black"	0.0 ± 9.5	0.0 ± 5.0	0.0 ± 3.9

COMPARISON OF THE VIRGIN ISLANDS STRAINS

There are no significant differences among the measures of size and of the bands among the samples from the various Virgin Islands. There may be a difference in the frequency with which spot B appears. It seems possible that this spot is less often present on the northern islands than on the southern ones. Hall's description of *punctata* suggests that the material from St. Kitts is even more prominently spotted than our St. Croix sample.

COMPARISON WITH OTHER STRAINS

Considerations of geography require that the Virgin Islands material need be compared only with that from Puerto Rico. It has already been pointed out that although there are real statistical differences between the series from these areas there is little to support taxonomic recognition of these differences. Absence of the species in the Windward Islands suggests that the Virgin Islands strains received no influence from the Amazonian strains

or from the strains found in the coastal belt of Venezuela. The statistics of the few variables studied bear out this supposition. The degree to which the secondary pattern of the forewings is developed on the Virgin Islands strain suggests that it may be considered taxonomically distinctive. Thus *Heliconius charitonius charitonius* (Linnaeus) should be restricted to those local strains that may be considered similar to the material from St. Thomas, the type locality of Linnaeus' insect. This would include all of the Virgin Islands strains, the Puerto Rican strains, and probably the unstudied strain from St. Kitts named *punctata* by Hall.

THE MEXICAN STRAIN, *HELICONIUS CHARITONIUS VASQUEZAE* COMSTOCK AND BROWN

The Sample

The Mexican population is represented by 84 males and 52 females. This is statistically adequate. The geographical distribution of the material studied leaves much to be desired. By far the preponderance of specimens come from the Gulf Coast region, principally from the state of Vera Cruz. While both the central and western parts of the Republic are represented, the series from these areas are overshadowed by the eastern material. It would be of some interest to see a large series of specimens from the west coast since many species in Mexico show definite differences on the two coasts. The seasonal distribution of the specimens studied may well represent the seasonal abundance of the species, with a summer peak from May into August and a winter peak in November and December.

Parameters

Central Tendencies: Males

Length of forewing	41.81 ± 0.25 mm.	*S.D.* = 3.43 mm.	*V* = 8.2
Width of band	2.35 ± 0.02 mm.	*S.D.* = 0.26 mm.	*V* =11.1
Band index	5.63 ± 0.04%	*S.D.* = 0.55%	*V* = 9.8

Central Tendencies: Females

Length of forewing	43.18 ± 0.30 mm.	*S.D.* = 3.19 mm.	*V* = 7.4
Width of band	2.54 ± 0.03 mm.	*S.D.* = 0.32 mm.	*V* =12.6
Band index	5.86 ± 0.05%	*S.D.* = 0.54%	*V* = 9.2

COEFFICIENTS OF CORRELATION

Males		
Length of forewing vs. width of band	$r = +0.4526$	$S.E. = 0.0868$
Length of forewing vs. band index	$r = -0.0974$	$S.E. = 0.1081$
Females		
Length of forewing vs. width of band	$r = +0.6458$	$S.E. = 0.0809$
Length of forewing vs. band index	$r = +0.0610$	$S.E. = 0.1382$

PATTERN AND COLOR FREQUENCIES

	Males	Females
A	11.9 ± 3.6	23.1 ± 6.0
B	95.2 ± 2.4	88.5 ± 4.4
C	19.0 ± 4.3	26.9 ± 6.1
D	2.4 ± 1.7	0.0 ± 1.9
E	100.0 ± 1.1	100.0 ± 1.9
F	1.2 ± 1.2	1.9 ± 1.9
"Ragged"	0.0 ± 1.1	0.0 ± 1.9
"Rusty"	2.3 ± 1.7	61.6 ± 6.7
"White"	0.0 ± 1.1	0.0 ± 1.9
"Black"	0.0 ± 1.1	0.0 ± 1.9

COMPARISON WITH ADJACENT STRAINS

Previously the Mexican strain has been compared with the strains from Florida, Cuba, Jamaica, and Hispaniola. It has been demonstrated that the Floridian and Jamaican strains are different from the strain found in Mexico. It has also been shown that the differences between the Mexican and the Cuban and Hispaniolan material are statistically valid, but that the biological differences are of questionable importance, and the differences are greater between the Mexican and Cuban than between the Mexican and Hispaniolan strains. It remains to discuss the Mexican and Central American strains.

SIZE: The Mexican strain does not differ in size from the Floridian or Central American strains. It is composed of materially larger insects than the Jamaican strain. The differences from the Cuban and Hispaniolan strains approach statistical validity, with the Mexican material being larger in both cases.

BAND INDEX: There is no significance in the slight difference between the band indices found for the Mexican and Central American samples studied. The bands on the Floridian and Hispaniolan strains are definitely narrower than those found on the Mexican strain, while the bands on the Jamaican material are definitely broader. The Cuban strain approaches the Mexican strain very closely in this respect. While the Cuban speci-

mens bear bands that are significantly broader from the statistical point of view, this difference is most difficult to see in the specimens.

MACULATION: The Mexican strain is typically mainland in this respect. However, the differences from other strains are slight. Only the Puerto Rican and Virgin Islands strains are really different from the Mexican in the degree to which the secondary pattern is developed on the forewings.

In respect to specific spots the following might be said:

Spot A appears less frequently on the Mexican material than on either the Floridian or Antillean material. In this respect the mainland strains all differ from the above-mentioned and are themselves homogeneous.

Spot C on the Mexican strain agrees in frequency more closely with the Floridian and Antillean strains (except from Jamaica) than with the Central and South American material.

Spot D occurs infrequently among Mexican specimens as it does on all mainland strains and the strain from Hispaniola.

Spot F also has the very low frequency shared with other mainland strains as opposed to the higher frequencies found among the Antillean material.

COLOR: The character "rusty" occurs with uniformly high frequency among the strains found in Mexico, Central America, and northwestern South America. These frequencies are approached by the strains from Florida and Hispaniola but nowhere else. While we have no evidence of "white" or "black" among the Mexican specimens studied, the very low frequency of these conditions suggest that the normal sampling error may be responsible.

CONCLUSIONS

There is no evidence that the Mexican and Central American strains are different. The differences between the Mexican and Antillean strains vary from very weak in the case of the Hispaniolan material to very strong in that from Jamaica. The differences from the Floridian strain seem to be significant. However, it is important to see a long series from Louisiana before the two can be declared different. The Floridian material may be at one end of a series of clines with the Colombian at the other. In only one minor color variation, "black," does the Colombian material differ from the Central American and Mexican.

THE CENTRAL AMERICAN STRAINS, *HELICONIUS CHARITONIUS VASQUEZAE* COMSTOCK AND BROWN

The Sample

There are 37 males and 26 females in the material studied. This is not adequate for the diverse conditions that prevail in Central America. None of the national samples is adequate. It is particularly important that at least adequate samples are studied from north and south of the Nicaragua-Costa Rica border. Until this is done, it cannot be said with certainty that the Central American population is truly homogeneous.

Parameters

Central Tendencies

Length of Forewing: Males

Guatemala	7	40.54 ± 0.61 mm.	*S.D.* = 2.19 mm.	*V* = 5.4
British Honduras	1	35.0 —	—	—
Honduras	11	39.73 ± 0.83 mm.	*S.D.* = 3.91 mm.	*V* = 9.8
El Salvador	2	39.35 ± 2.53 mm.	*S.D.* = 3.75 mm.	*V* = 9.5
Nicaragua	3	42.85 ± 1.76 mm.	*S.D.* = 3.68 mm.	*V* = 8.6
Costa Rica	1	33.0 mm.		
Panama	12	42.76 ± 0.58 mm.	*S.D.* = 2.84 mm.	*V* = 6.4
Central America	37	40.67 ± 0.40 mm.	*S.D.* = 3.58 mm.	*V* = 8.8

Length of Forewing: Females

Guatemala	3	40.83 ± 1.46 mm.	*S.D.* = 3.07 mm.	*V* = 7.5
British Honduras	1	43.4 mm.		
Honduras	7	42.57 ± 1.25 mm.	*S.D.* = 4.53 mm.	*V* = 10.7
Nicaragua	1	38.5 mm.		
Costa Rica	5	43.30 ± 1.01 mm.	*S.D.* = 2.98 mm.	*V* = 6.9
Panama	9	43.12 ± 0.52 mm.	*S.D.* = 2.19 mm.	*V* = 5.1
Central America	26	42.58 ± 0.44 mm.	*S.D.* = 3.22 mm.	*V* = 7.0

Width of Band: Males

Guatemala	7	2.47 ± 0.09 mm.	*S.D.* = 0.34 mm.	*V* = 13.6
British Honduras	1	2.0 mm.		
Honduras	11	2.25 ± 0.06 mm.	*S.D.* = 0.29 mm.	*V* = 12.6
El Salvador	2	2.10 ± 0.09 mm.	*S.D.* = 0.14 mm.	*V* = 6.7
Nicaragua	3	2.40 ± 0.18 mm.	*S.D.* = 0.38 mm.	*V* = 15.8
Costa Rica	1	1.6 mm.		
Panama	12	2.43 ± 0.09 mm.	*S.D.* = 0.41 mm.	*V* = 17.1
Central America	37	2.33 ± 0.04 mm.	*S.D.* = 0.35 mm.	*V* = 15.2

Width of Band: Females

Guatemala	3	2.43 ± 0.11 mm.	*S.D.* = 0.24 mm.	*V* = 10.0
British Honduras	1	2.7 mm.		
Honduras	7	2.70 ± 0.11 mm.	*S.D.* = 0.38 mm.	*V* = 14.1
Nicaragua	1	2.2 mm.		
Costa Rica	5	2.56 ± 0.02 mm.	*S.D.* = 0.07 mm.	*V* = 2.7
Panama	9	2.61 ± 0.04 mm.	*S.D.* = 0.17 mm.	*V* = 6.3
Central America	26	2.61 ± 0.03 mm.	*S.D.* = 0.25 mm.	*V* = 9.6

Band Index: Males

Guatemala	7	6.09 ± 0.21%	*S.D.* = 0.76%	*V* = 12.4
British Honduras	1	5.7%		
Honduras	11	5.71 ± 0.11%	*S.D.* = 0.51%	*V* = 8.9
El Salvador	2	5.40 ± 0.57%	*S.D.* = 0.85%	*V* = 15.7
Nicaragua	3	5.63 ± 0.19%	*S.D.* = 0.41%	*V* = 7.3
Costa Rica	1	4.8%		
Panama	12	5.72 ± 0.15%	*S.D.* = 0.77%	*V* = 13.5
Central America	37	5.74 ± 0.07%	*S.D.* = 0.64%	*V* = 11.2

Band Index: Females

Guatemala	3	6.00 ± 0.35%	*S.D.* = 0.74%	*V* = 12.3
British Honduras	1	6.2%		
Honduras	11	6.36 ± 0.15%	*S.D.* = 0.56%	*V* = 8.8
Nicaragua	1	5.7%		
Costa Rica	5	5.92 ± 0.14%	*S.D.* = 0.42%	*V* = 7.1
Panama	9	6.14 ± 0.07%	*S.D.* = 0.30%	*V* = 4.9
Central America	26	6.12 ± 0.06%	*S.D.* = 0.46%	*V* = 7.5

Coefficients of Correlation

Males

Length of forewing vs. width of band	*r* = +0.6786	*S.E.* = 0.0887
Length of forewing vs. band index	*r* = +0.0276	*S.E.* = 0.1643

Females

Length of forewing vs. width of band	*r* = +0.6093	*S.E.* = 0.1233
Length of forewing vs. band index	*r* = −0.2810	*S.E.* = 0.1806

Pattern and Color Frequencies: Males

	Guatemala	Honduras	Nicaragua	Panama	Central America
A	28.6 ± 17.1	0.0 ± 7.8	66.7 ± 27.0	0.0 ± 7.2	13.5 ± 6.2
B	71.5 ± 17.1	72.7 ± 13.4	100.0 ± 21.7	100.0 ± 7.2	86.5 ± 6.2
C	14.3 ± 13.1	0.0 ± 7.8	33.3 ± 27.0	0.0 ± 7.2	8.1 ± 5.4
D	0.0 ± 11.5	0.0 ± 7.8	0.0 ± 21.7	0.0 ± 7.2	0.0 ± 2.9
E	100.0 ± 11.5	100.0 ± 7.8	100.0 ± 21.7	100.0 ± 7.2	100.0 ± 2.9
F	0.0 ± 11.5	0.0 ± 7.8	0.0 ± 21.7	0.0 ± 7.2	0.0 ± 2.9
"Ragged"	0.0 ± 11.5	0.0 ± 7.8	0.0 ± 21.7	0.0 ± 7.2	0.0 ± 2.9
"Rusty"	0.0 ± 11.5	18.2 ± 13.4	33.3 ± 27.0	0.0 ± 7.2	8.1 ± 5.4
"White"	0.0 ± 11.5	0.0 ± 7.8	0.0 ± 21.7	0.0 ± 7.2	0.0 ± 2.9
"Black"	14.3 ± 13.1	0.0 ± 7.8	0.0 ± 21.7	0.0 ± 7.2	2.7 ± 3.0

PATTERN AND COLOR FREQUENCIES: FEMALES

A	0.0 ± 21.7	0.0 ± 11.5	20.0 ± 17.8	33.3 ± 15.7	15.4 ± 6.7
B	100.0 ± 21.7	57.2 ± 18.7	60.0 ± 22.0	77.8 ± 13.8	69.3 ± 8.8
C	0.0 ± 21.7	42.8 ± 18.7	40.0 ± 22.0	11.1 ± 10.4	26.9 ± 9.6
D	0.0 ± 21.7	0.0 ± 11.5	0.0 ± 15.3	0.0 ± 9.5	0.0 ± 3.8
E	100.0 ± 21.7	100.0 ± 11.5	100.0 ± 15.3	100.0 ± 9.5	100.0 ± 3.8
F	0.0 ± 21.7	0.0 ± 11.5	0.0 ± 15.3	22.2 ± 13.8	7.7 ± 5.4
"Ragged"	0.0 ± 21.7	0.0 ± 11.5	0.0 ± 15.3	0.0 ± 9.5	0.0 ± 3.8
"Rusty"	100.0 ± 21.7	57.2 ± 18.7	80.0 ± 17.8	66.7 ± 15.7	65.4 ± 9.3
"White"	0.0 ± 21.7	0.0 ± 11.5	0.0 ± 15.3	0.0 ± 9.5	0.0 ± 3.8
"Black"	0.0 ± 21.7	0.0 ± 11.5	0.0 ± 15.3	0.0 ± 9.5	0.0 ± 3.8

COMPARISON WITH ADJACENT STRAINS

As might be expected, the Central American strains show no real differences from the Mexican or northwestern South American strains. From the Antillean strains the material studied differs sharply from the Jamaican strain, somewhat from the Hispaniolan, and little from the Cuban, strain.

SIZE: The Central American material studied differs in size only from the Jamaican and Colombian strains. The difference from the Jamaican material is significant and real. As has been pointed out, the almost significant difference between the Central American and Colombian series may be entirely clinal.

BAND INDEX: The bands on the Central American specimens are intermediate to those found on the Mexican and Colombian series. This is as might be expected. When compared with the strains from the Greater Antilles, the Central American strains are seen to bear bands that are narrower than those on the Jamaican insects, broader than those on the Hispaniolan, and insignificantly narrower than those on the Cuban, strain.

MACULATION: The degree to which the secondary pattern is developed on the forewing of the Central American strain does not differ significantly from any adjacent strain.

COLOR: The condition "rusty" reaches its peak in Central America. However, although higher, the frequency is not significantly different from that found in Colombia or in Mexico. Among the Antillean strains only the strain from Hispaniola approaches the condition found on the mainland. It is possible that the condition "rusty" has arisen independently in Hispaniola and therefore, although there is no real significant difference in the two areas, there is a real genetic difference. The only other secondary color that appears among Central American specimens

is "black." A single male in the Reading Public Library and Museum from "Copan, Guatemala" (Copan, Honduras, or Coban, Guatemala?) exhibits "black." This character is rather common in South American strains; it is rare or absent (?) elsewhere. Since many Mengel collection locality labels are known to be faulty, further specimens are needed to confirm "black" in Central America.

Conclusions

So far as measurements are concerned the strain of *charitonius* that inhabits Central America does not differ from that found in Mexico or that from northwestern South America. There is no evidence of difference from the Mexican material. The high frequency of "black" on Colombian specimens suggests that these are different from the Central American. Among the Antillean specimens studied the strain from Cuba does not seem to vary very much from the Central American strain, except that the Cuban lacks a high frequency for "rusty." The material from the other islands each has some minor point of difference from the Central American.

THE COLOMBIAN STRAIN, *HELICONIUS CHARITONIUS BASSLERI* COMSTOCK AND BROWN

The Sample

The Colombian series consists of 64 males and 20 females. Only the male series is statistically adequate. By far the major portion of the specimens came from the western part of the country and particularly from the Province of Cauca. Better representation of the eastern part of the country would be desirable. Seasonally, too, there is much to be desired. Of the dated specimens 88 per cent were taken in August and September, the others in November, January, and February.

Parameters

Central Tendencies: Males

Length of forewing	37.84 ± 0.22 mm.	*S.D.* = 2.53 mm.	*V* = 6.7
Width of band	2.26 ± 0.02 mm.	*S.D.* = 0.22 mm.	*V* = 9.7
Band index	5.97 ± 0.04%	*S.D.* = 0.45%	*V* = 7.5

Central Tendencies: Females

Length of forewing	42.58 ± 0.44 mm.	*S.D.* = 3.22 mm.	*V* = 7.5
Width of band	2.45 ± 0.04 mm.	*S.D.* = 0.29 mm.	*V* = 11.8
Band index	6.25 ± 0.08%	*S.D.* = 0.51%	*V* = 8.1

COEFFICIENTS OF CORRELATION

Males		
Length of forewing vs. width of band	$r = +0.5749$	$S.E. = \pm 0.0837$
Length of forewing vs. band index	$r = -0.1876$	$S.E. = \pm 0.1206$
Females		
Length of forewing vs. width of band	$r = +0.6367$	$S.E. = \pm 0.1330$
Length of forewing vs. band index	$r = -0.0527$	$S.E. = \pm 0.2230$

PATTERN AND COLOR FREQUENCIES

	Males	Females
A	15.6 ± 4.5	15.0 ± 8.0
B	93.7 ± 3.0	80.0 ± 9.0
C	10.9 ± 3.9	10.0 ± 6.5
D	0.0 ± 1.7	0.0 ± 4.8
E	92.2 ± 3.3	95.0 ± 5.0
F	0.0 ± 1.7	0.0 ± 4.8
"Ragged"	0.0 ± 1.7	0.0 ± 4.8
"Rusty"	0.0 ± 1.7	60.0 ± 11.0
"White"	0.0 ± 1.7	0.0 ± 4.8
"Black"	25.0 ± 5.5	0.0 ± 4.8

COMPARISON WITH ADJACENT STRAINS

The Colombian material does not differ significantly from the Amazonian material from Ecuador and Peru, or from the Central American material except in the frequency for "black." It is totally different from the west coast material from Ecuador and Peru.

CONCLUSIONS

It is a matter of opinion whether the Colombian and Central American material should be taxonomically separated. The high frequency for "black" among the Colombian specimens is a strong indication of a different genetic complex. However, this is not supported statistically by any other character.

THE AMAZONIAN STRAIN, *HELICONIUS CHARITONIUS BASSLERI* COMSTOCK AND BROWN

THE SAMPLE

This is the least satisfactory sample studied. To Comstock's original data Brown has added those from three males from eastern Ecuador in his collection. The series studied consists of 11 males and three females from northeastern Peru, three males from central eastern Ecuador, and two pairs from Venezuela. The

parameters based on this small lot of miscellaneous specimens are of little value but are presented with the hope that someone can and will make further studies of the species in the Amazon basin. The Venezuelan material has not been included in the statistics labeled "Amazonia." There is some evidence that the Venezuelan strain is not wholly consonant with the Amazonian. It is quite possible that some of the Colombian material used in the study of that strain should be included in the Amazonian strain.

Parameters

Central Tendencies

	N	Mean	*P.E.*	*S.D.*	*V*
Length of Forewing: Males					
Northeastern Peru	11	38.23 ± 0.39 mm.		1.82 mm.	4.8
Eastern Ecuador	3	38.73 ± 0.23 mm.		0.48 mm.	1.3
Amazonia	14	38.34 ± 0.30 mm.		1.62 mm.	4.2
Venezuela	2	35.55 ± 2.91 mm.		4.31 mm.	12.1
Length of Forewing: Females					
Northeastern Peru	3	39.60 ± 1.87 mm.		3.93 mm.	9.9
Venezuela	2	35.10 ± 0.86 mm.		1.27 mm.	3.7
Width of Band: Males					
Northeastern Peru	11	2.26 ± 0.04 mm.		0.21 mm.	9.3
Eastern Ecuador	3	3.00 ± 0.05 mm.		0.10 mm.	3.3
Amazonia	14	2.42 ± 0.07 mm.		0.36 mm.	14.9
Venezuela	2	2.35 ± 0.33 mm.		0.49 mm.	20.8
Width of Band: Females					
Northeastern Peru	3	2.54 ± 0.14 mm.		0.28 mm.	11.0
Venezuela	2	2.35 ± 0.14 mm.		0.21 mm.	9.0
Band Index: Males					
Northeastern Peru	11	5.91 ± 0.09%		0.43%	7.3
Eastern Ecuador	3	7.73 ± 0.17%		0.35%	4.5
Amazonia	14	5.94 ± 0.18%		0.97%	16.3
Venezuela	2	6.60 ± 0.21%		1.13%	17.1
Band Index: Females					
Northeastern Peru	3	6.50 ± 0.21%		0.44%	6.8
Venezuela	2	6.65 ± 0.24%		0.35%	5.3

Coefficients of Correlation

Amazonia males

Length of forewing vs. width of band	$r = +0.3307$	*S.E.* = 0.2380
Length of forewing vs. band index	$r = +0.1519$	*S.E.* = 0.2945

PATTERN AND COLOR FREQUENCIES: MALES

	Northeastern Peru	Eastern Ecuador[a]	Amazonia	Venezuela[a]
A	18.2 ± 11.8	0.0	14.3 ± 9.2	0.0
B	100.0 ± 8.2	33.3	85.7 ± 9.2	50.0
C	9.1 ± 8.6	0.0	7.2 ± 6.7	0.0
D	0.0 ± 8.2	0.0	0.0 ± 6.6	0.0
E	90.9 ± 8.6	100.0	92.9 ± 6.7	100.0
F	9.1 ± 8.6	0.0	7.2 ± 6.7	0.0
"Ragged"	0.0 ± 8.2	0.0	0.0 ± 6.6	0.0
"Rusty"	0.0 ± 8.2	0.0	0.0 ± 6.6	0.0
"Black"	36.4 ± 14.5	33.3	35.7 ± 12.0	0.0
"White"	0.0 ± 8.2	0.0	0.0 ± 6.6	50.0

PATTERN AND COLOR FREQUENCIES: FEMALES

	Northeastern Peru[a]	Venezuela[a]
A	0.0	50.0
B	100.0	100.0
C	0.0	50.0
D	0.0	0.0
E	100.0	100.0
F	0.0	50.0
"Ragged"	0.0	0.0
"Rusty"	33.3	0.0
"White"	0.0	0.0
"Black"	33.3	0.0

[a] These samples are too small to have any meaning.

COMPARISON WITH ADJACENT STRAINS

The Amazonian material does not differ significantly from the Colombian strain. It differs in many respects from the material found on the west coast of Ecuador and Peru. The Venezuelan material seems to show differences that may, on study of an adequate series, prove to be significant. The following points are suggested by the two pairs of Venezuelan specimens:

SIZE: Both sexes may be appreciably smaller than those of adjacent strains and approach those from Jamaica in this respect.

WIDTH OF BAND: Probably not different from other South American material.

MACULATION: It is possible that the females are more maculate than the other South American strains.

COLOR: One of the Venezuelan males shows the character "white" seen otherwise only in Florida and Cuba. However, the frequency for this color change is so low that it may well be present in the strains where our samples now show it to be absent.

Conclusions

Nothing is settled about the material from east of the Andes by these few specimens. The only course to follow is to regard them as the same as are found in Colombia until adequate series are available and studied. There is some slight evidence that the Venezuelan material may prove distinctive.

The West Coast Strains, *Heliconius charitonius peruviana* C. and R. Felder

The Sample

Comstock had before him 22 males and 17 females of *peruviana*. To this Brown added the data from four males from Ecuador in his collection. The samples are statistically inadequate. Since all the Peruvian material comes from Lima and all the Ecuadorean from Guayaquil, more or less the south and north extremities of the range, it is to be expected that the two series show some differences. Whether or not these differences are of taxonomic importance can be demonstrated only by adequate samples from several places in addition to Lima and Guayaquil.

Parameters

Central Tendencies

Length of Forewing: Males

	N	Mean	*P.E.*	*S.D.*	*V*
Peru	19	32.86 ± 0.28 mm.		1.73 mm.	5.2
Ecuador	7	36.71 ± 0.28 mm.		1.00 mm.	2.7
West coast	26	33.90 ± 0.32 mm.		2.35 mm.	7.0

Length of Forewing: Females

Peru	12	34.33 ± 0.36 mm.		1.76 mm.	5.1
Ecuador	5	38.88 ± 0.89 mm.		2.65 mm.	6.8
West coast	17	35.67 ± 0.52 mm.		3.06 mm.	8.6

Width of Band: Males

	N	Mean	*P.E.*	*S.D.*	*V*
Peru	19	2.93 ± 0.04 mm.		0.28 mm.	9.5
Ecuador	7	3.20 ± 0.13 mm.		0.48 mm.	15.0
West coast	26	3.00 ± 0.05 mm.		0.35 mm.	11.7

Width of Band: Females

Peru	12	3.25 ± 0.09 mm.		0.43 mm.	13.2
Ecuador	7	3.50 ± 0.19 mm.		0.56 mm.	16.0
West coast	17	3.32 ± 0.08 mm.		0.45 mm.	13.6

Band Indices: Males

	N	Mean	*P.E.*	*S.D.*	*V*
Peru	19	8.92 ± 0.14%		0.86%	9.6
Ecuador	7	8.67 ± 0.27%		0.98%	11.3
West coast	26	8.85 ± 0.12%		0.88%	9.9

Band Indices: Females

Peru	12	9.47 ± 0.21%		1.03%	10.9
Ecuador	5	8.96 ± 0.16%		0.93%	10.4
West coast	17	9.32 ± 0.17%		1.00%	10.7

COEFFICIENTS OF CORRELATION

Males

Length of wing vs. width of band	$r = +0.2546$	*S.E.* = 0.1994
Length of wing vs. band index	$r = -0.3380$	*S.E.* = 0.1889

Females

Length of wing vs. width of band	$r = +0.5639$	*S.E.* = 0.1654
Length of wing vs. band index	$r = -0.1483$	*S.E.* = 0.2372

PATTERN AND COLOR FREQUENCIES: MALES[a]

	Peru	Ecuador	West Coast
A	0.0 ± 4.9	0.0 ± 11.5	0.0 ± 3.3
B	100.0 ± 4.9	71.4 ± 17.1	92.3 ± 5.3
C	0.0 ± 4.9	0.0 ± 11.5	0.0 ± 3.3
D	0.0 ± 4.9	0.0 ± 11.5	0.0 ± 3.3
E	100.0 ± 4.9	85.7 ± 13.1	96.2 ± 3.7
F	0.0 ± 4.9	0.0 ± 11.5	0.0 ± 3.3
"Black"	36.8 ± 11.1	71.4 ± 17.1	46.1 ± 9.8
"Yellow"	10.5 ± 7.0	0.0 ± 11.5	7.7 ± 5.3
"Tips"	0.0 ± 4.9	0.0 ± 11.5	0.0 ± 3.3

PATTERN AND COLOR FREQUENCIES: FEMALES

	Peru	Ecuador	West Coast
A	0.0 ± 7.5	0.0 ± 15.3	0.0 ± 5.6
B	100.0 ± 7.5	100.0 ± 15.3	100.0 ± 5.6
C	0.0 ± 7.5	0.0 ± 15.3	0.0 ± 5.6
D	0.0 ± 7.5	0.0 ± 15.3	0.0 ± 5.6
E	100.0 ± 7.5	100.0 ± 15.3	100.0 ± 5.6
F	0.0 ± 7.5	0.0 ± 15.3	0.0 ± 5.6
"Black"	0.0 ± 7.5	80.0 ± 17.8	23.5 ± 10.3
"Yellow"	8.3 ± 7.8	0.0 ± 15.3	5.9 ± 5.8
"Tips"	16.7 ± 10.8	40.0 ± 22.0	35.3 ± 11.5

[a] In the frequency tables "ragged," "rusty," and "white" have been omitted. None of these appeared in the sample studied. "Black" has the same meaning as in the previous tables. "Yellow" indicates the condition where the second band on the forewing is yellow, not white, and "tips" where the yellow bands are tipped with white. These two conditions occur only in *peruviana*.

Comparison with Adjacent Strains

The coastal material from the Rio Guayas in Ecuador southward to Lima, Peru, differs from all other strains studied in pattern and normal coloration. These insects also are the smallest in size of the groups studied. The bands that mark them are wider, absolutely and proportionally, than on any other samples. The conditions "yellow" and "tips" are found in no other strain. The small size of the samples from Ecuador and Peru does not allow a firm statement to be made about "white" or "rusty." It might be said though that if "rusty" does occur in the coastal strains its frequency is low for a mainland strain.

The series of *peruviana* studied are not large enough to state definitely whether or not the Peruvian material differs enough from the Ecuadorean to require a name for the latter. These differences between the local strains from Lima and Guayaquil are suggested:

Size: The Ecuadorean material is significantly larger than the Peruvian.

Bands: The bands on the Ecuadorean specimens tend to be insignificantly narrower than on the Peruvian.

Pattern: The Ecuadorean males tend to be a little less fully marked than the Peruvian males.

Color: "Black" seems to be much more frequent in Ecuador than in Peru. The samples are too small to do more than suggest that "yellow" is more frequent in Peru and that "tips" are more frequent in Ecuador.

Conclusions

The west coast strains are so distinctive that they may well represent a different species from *charitonius*. On the other hand the male genitalia of the specimens examined are like those of *charitonius*. Just how satisfactory this character is must be further demonstrated. Until more concrete evidence is brought forth than we have accumulated, it will be a matter of personal opinion whether *peruviana* is treated as a highly distinctive subspecies of *charitonius* or a close but distinct species.

General Conclusions

This and the preceding paper by Comstock and Brown are two different approaches to the solution of a common problem:

Are the various local strains of *Heliconius charitonius* separable into recognizable subspecies? The first paper, prepared entirely by Comstock, approached the problem by the usual empirical means. He examined long series of specimens from various localities, discovered apparently constant differences, and decided which of these were sufficient to set the material from an area apart from all other material. What measurements he used were handled in the usual way of taxonomists. This, the second paper, was prepared entirely by Brown from data supplied by Comstock. In it the approach has been entirely statistical without reference to the specimens. In fact it was prepared some 1800 miles from them! Since a limited number of variables was analyzed, it is to be expected that the statistical approach will yield more conservative results.

Comstock segregated eight distinctive populations. These are:

charitonius Linnaeus, from the Virgin Islands and Puerto Rico
simulator Roeber, from Jamaica
ramsdeni Comstock and Brown, from Cuba
churchi Comstock and Brown, from Hispaniola
tuckeri Comstock and Brown, from Florida
vasquezae Comstock and Brown, from Mexico and Central America
bassleri Comstock and Brown, from northwestern South America
peruviana C. and R. Felder, from the coast of Peru and Ecuador

Hall's subspecies *punctata* from St. Kitts was not examined but apparently is synonymous with *charitonius* Linnaeus.

TABLE 13

NUMBER OF POINTS OF DIFFERENCE BETWEEN ADJACENT POPULATIONS

	F.	C.	J.	H.	P.R.	V.I.	M.	C.A.	C.	A.	W.C.
Florida	—	2	3	2	—	—	2	—	—	—	—
Cuba	2	—	2	2	—	—	2	1	—	—	—
Jamaica	3	2	—	3	—	—	3	3	—	—	—
Hispaniola	2	2	3	—	2	—	1	1	—	—	—
Puerto Rico	—	—	—	2	—	1	3	1	—	—	—
Virgin Islands	—	—	—	—	1	—	—	—	2	2	—
Mexico	2	2	3	1	3	—	—	0	1	—	—
Central America	—	1	3	1	1	—	0	—	1	—	3
Colombia	—	—	—	—	—	2	1	1	—	0	3
Amazonia	—	—	—	—	—	2	—	—	0	—	3
West coast	—	—	—	—	—	—	—	3	3	3	—

Brown examined the data grouped into 24 "strains." These were later regrouped into 11 more or less homogeneous populations. Each of these is treated separately above. Where a population is composed of more than one strain the data are presented for each strain as well as for the amalgamated population.

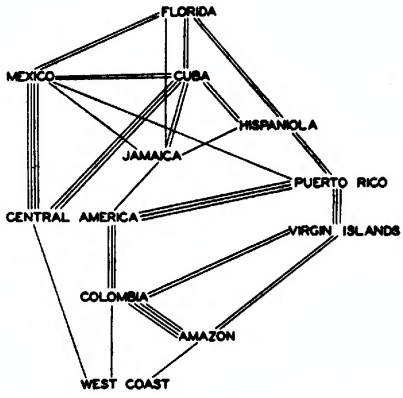

FIG. 8. Relationships of the different populations with regard to number of points of difference. Each line represents an agreement. The maximum number of points in agreement possible is four.

The data that were studied statistically can be grouped into those dealing with size, the bands, the pattern, and coloration. Each population was compared with the adjacent populations to see if two adjacent populations might have been drawn from a single super-population. If they could not, they were considered to be significantly different. The results of this final analysis are given in table 13.

Twenty-six pairs were tested for each character; thus 104 tests were made. Significant differences were found in 48 instances. Differences in the secondary color characters occurred 19 times, in the width of the bands 17 times, in size nine times, and in maculation only three times.

Now let us examine these data in the light of Comstock's taxonomic conclusions. The Mexican and Central American populations show no statistical differences for the variables studied. Comstock grouped these, and only these, as *charitonius vasquezae*. The same can be said of the Colombian and Amazonian strains that were grouped as *charitonius bassleri*.

Six pairs of strains show only one significant difference among the four possibly different characters. Summarizing these, it can be said that *ramsdeni* from Cuba differs from *vasquezae* from Central America in "rusty"; that *churchi* from Hispaniola differs from *vasquezae* from Middle America in bearing narrower bands; that *charitonius* from Puerto Rico differs from typical *charitonius* from the Virgin Islands in being less maculate and from *vasquezae* in being almost free of "rusty"; that *vasquezae* from Middle America differs from *bassleri* from northwestern South America in lacking "black." Thus a single difference has been recognized taxonomically by Comstock in each instance but one. The difference in maculation was not considered of sufficient weight to separate the populations from Puerto Rico and the Virgin Islands.

In every instance where two or three statistical differences were proved Comstock recognized a taxonomic difference. In no case were four differences found. This condition almost prevails between *peruviana* and all other populations.

In conclusion it can be said that the biometrics of the species *Heliconius charitonius* bear out Comstock's taxonomic study, provided differences are considered significant only if they are seven or more times their probable errors.